

---

**TDS-9S**

**Top Drive  
Drilling  
System**

**Service Manual**

---

**SM00001**

**Rev. A**

March 9, 1998

# Contents

## Book 1 – Description

---

### Preface/Manual conventions

|                              |     |
|------------------------------|-----|
| Safety information .....     | 1-5 |
| Directional references ..... | 1-6 |
| Manual layout .....          | 1-6 |

### Chapter 1 Overview

|                    |     |
|--------------------|-----|
| Introduction ..... | 1-7 |
|--------------------|-----|

### Chapter 2 Major component description

|                                                                     |      |
|---------------------------------------------------------------------|------|
| Introduction .....                                                  | 1-9  |
| AC drilling motors .....                                            | 1-10 |
| Motor cooling system .....                                          | 1-14 |
| Transmission/motor housing (main body)<br>and swivel assembly ..... | 1-16 |
| Counterbalance system .....                                         | 1-18 |
| Carriage and guide beam .....                                       | 1-20 |
| Hydraulic control system .....                                      | 1-22 |
| PH-50 Pipehandler .....                                             | 1-25 |
| Rotating link adapter .....                                         | 1-26 |
| Torque back-up clamp .....                                          | 1-28 |
| Two-way link tilt .....                                             | 1-29 |
| Internal Blowout Prevention (IBOP) .....                            | 1-30 |
| Drill pipe elevator .....                                           | 1-31 |
| Driller's console .....                                             | 1-32 |
| Throttle .....                                                      | 1-32 |
| Torque limit potentiometer .....                                    | 1-32 |
| Makeup limit potentiometer .....                                    | 1-32 |
| Switches and buttons .....                                          | 1-33 |
| Indicator lights .....                                              | 1-33 |

Service loop ..... 1-35

Variable frequency inverter (VFI) ..... 1-36

    Rectifier/capacitor ..... 1-36

    Power modules ..... 1-36

    Control sections ..... 1-36

Chapter 3 Specifications

AC drilling motors ..... 1-39

Variable frequency inverter (VFI) ..... 1-39

Motor braking ..... 1-39

Motor cooling system ..... 1-40

Electrical service loop ..... 1-40

Gearcase ..... 1-41

Gearcase lubrication ..... 1-41

Hydraulic system ..... 1-41

System specifications ..... 1-41

Diagrams ..... 1-42



# Book 2 – Installation

---

## Chapter 1 Preparation

|                                                       |      |
|-------------------------------------------------------|------|
| Preparation and pre-installation considerations ..... | 2-5  |
| Pre-installation checklist .....                      | 2-10 |

## Chapter 2 Installation

|                                                            |      |
|------------------------------------------------------------|------|
| Installing the guide beam and lower attachment .....       | 2-11 |
| Installing the rotary hose .....                           | 2-20 |
| Installing the derrick electrical termination .....        | 2-20 |
| Installing the driller's console and instrumentation ..... | 2-22 |
| Varco driller's console (VDC) .....                        | 2-22 |
| Wiring .....                                               | 2-22 |
| Installing the electrical service loop .....               | 2-23 |
| Installing the counterbalance system .....                 | 2-26 |
| Installing the tool joint lock .....                       | 2-28 |
| Removing the tool joint lock.....                          | 2-32 |
| Reinstalling the tool joint lock .....                     | 2-32 |

## Chapter 3 Commissioning

|                                                     |      |
|-----------------------------------------------------|------|
| Checkout procedure.....                             | 2-33 |
| Hydraulic system .....                              | 2-33 |
| Checking the fluid level and filter condition ..... | 2-33 |
| Pre-charging the accumulators .....                 | 2-36 |
| Setting up the pumps .....                          | 2-40 |
| Setting up the counterbalance circuit .....         | 2-44 |
| Setting up the brake circuit .....                  | 2-46 |
| Setting up the rotating link adapter circuit .....  | 2-46 |
| Setting up the IBOP actuator circuit .....          | 2-46 |
| Setting up the shot pin cylinder circuit .....      | 2-46 |
| Setting up the link tilt circuit .....              | 2-48 |
| Electrical system.....                              | 2-49 |
| Long term TDS-9S storage procedures .....           | 2-50 |
| Returning the TDS-9S to service after storage.....  | 2-52 |
| TDS-9S Installation checklist (FIP00003) .....      | 2-52 |

## Installation Checklist (FIP00003)

---

## Book 3 – Operation

---

### Chapter 1 Varco Driller's Console

### Chapter 2 Operating procedures

|                                                     |      |
|-----------------------------------------------------|------|
| Start-up procedure .....                            | 3-9  |
| Pipehandler operation .....                         | 3-12 |
| Rotating link adapter .....                         | 3-12 |
| IBOP safety valves .....                            | 3-12 |
| Torque backup clamp .....                           | 3-14 |
| Link tilt .....                                     | 3-14 |
| Tool joint locks .....                              | 3-17 |
| Torque values for load carrying components .....    | 3-17 |
| Changing drill string sizes .....                   | 3-18 |
| Drilling ahead .....                                | 3-18 |
| Drilling ahead with triples .....                   | 3-18 |
| Drilling ahead with singles .....                   | 3-22 |
| Tripping .....                                      | 3-25 |
| Reaming out .....                                   | 3-26 |
| Well control procedures .....                       | 3-28 |
| Running casing .....                                | 3-32 |
| Post jarring operations .....                       | 3-33 |
| Post jarring checklist/design torque standard ..... | 3-33 |

## Post Jarring Checklist (PI 93-1)

---

## Design Specification, Design Torque Standard (DS00008)

---

# Book 4 – Maintenance and Troubleshooting

---

## Preface/Manual conventions

|                              |     |
|------------------------------|-----|
| Safety information .....     | 4-7 |
| Directional references ..... | 4-8 |
| Manual layout.....           | 4-8 |

## Chapter 1 Introduction

|                   |     |
|-------------------|-----|
| Precautions ..... | 4-9 |
|-------------------|-----|

## Chapter 2 Maintenance schedules

|                                |      |
|--------------------------------|------|
| Inspection schedules .....     | 4-11 |
| Lubrication schedules.....     | 4-13 |
| Lubricant specifications ..... | 4-14 |
| Selecting a gear oil .....     | 4-14 |
| Selecting a lubricant .....    | 4-15 |

## Chapter 3 Inspection

|                                                        |      |
|--------------------------------------------------------|------|
| Inspecting hardware and fittings .....                 | 4-17 |
| Inspecting the AC drilling motor brakes .....          | 4-17 |
| Inspecting the AC drilling motor louvers .....         | 4-19 |
| Inspecting the S-pipe .....                            | 4-20 |
| Inspecting the wash pipe assembly .....                | 4-20 |
| Inspecting the upper stem liner .....                  | 4-21 |
| Inspecting main shaft end play .....                   | 4-22 |
| Inspecting gear backlash .....                         | 4-23 |
| Inspecting the gearbox oil level .....                 | 4-24 |
| Inspecting the lubrication oil flow.....               | 4-25 |
| Inspecting the gearbox lubrication pump assembly ..... | 4-26 |
| Inspecting the guide beam .....                        | 4-28 |
| Inspecting the IBOPs .....                             | 4-28 |
| Inspecting the pipehandler .....                       | 4-28 |
| Nondestructive Examination (NDE) .....                 | 4-29 |
| Inspecting the elevator link eyes .....                | 4-30 |
| Inspecting the drive stem .....                        | 4-31 |
| Magnetic Particle Inspection (MPI) .....               | 4-32 |
| Ultrasonic inspection .....                            | 4-33 |
| Inspecting the hydraulic system .....                  | 4-34 |
| Inspecting the electrical system .....                 | 4-36 |

## Chapter 4 Lubrication

|                                                                         |      |
|-------------------------------------------------------------------------|------|
| Introduction .....                                                      | 4-37 |
| Lubricating the AC blower motor bearings .....                          | 4-38 |
| Lubricating the hydraulic pump AC motor .....                           | 4-39 |
| Lubricating the AC drilling motor bearings .....                        | 4-40 |
| Lubricating the wash pipe assembly .....                                | 4-42 |
| Lubricating the upper main body oil seals .....                         | 4-43 |
| Replacing the gearbox oil .....                                         | 4-44 |
| Initial oil change .....                                                | 4-44 |
| Oil capacity .....                                                      | 4-45 |
| Replacing the gearbox oil filter .....                                  | 4-46 |
| Lubricating the bail pins .....                                         | 4-46 |
| Lubricating the lower main body oil seals .....                         | 4-46 |
| Lubricating the roller carriage assembly .....                          | 4-47 |
| Lubricating the rotating link adapter .....                             | 4-48 |
| Lubricating the link tilt and PH-50<br>stabilizer bushing .....         | 4-49 |
| Lubricating the elevator support and<br>master bushing wear guide ..... | 4-50 |
| Lubricating the wireline adapter .....                                  | 4-51 |
| Lubricating the IBOP actuator yoke .....                                | 4-52 |
| Lubricating the IBOP actuator crank .....                               | 4-53 |
| Lubricating the torque arrestor tubes and<br>clamp cylinder gate .....  | 4-54 |

## Chapter 5 Maintenance

|                                             |      |
|---------------------------------------------|------|
| General hydraulic system maintenance .....  | 4-55 |
| Changing the hydraulic filter and oil ..... | 4-56 |
| Start-up procedure .....                    | 4-58 |
| Accumulator maintenance .....               | 4-58 |

## Chapter 6 Troubleshooting

|                                                                          |      |
|--------------------------------------------------------------------------|------|
| Troubleshooting the AC drilling motors .....                             | 4-59 |
| Troubleshooting the AC blower motors .....                               | 4-60 |
| Troubleshooting the hydraulic system .....                               | 4-61 |
| Troubleshooting the AC drilling<br>motor brakes .....                    | 4-66 |
| Troubleshooting the rotating link adapter<br>(rotating head) motor ..... | 4-68 |
| Operation .....                                                          | 4-68 |
| System test .....                                                        | 4-68 |
| Troubleshooting the IBOP actuator cylinder .....                         | 4-71 |
| Operation .....                                                          | 4-71 |
| System test .....                                                        | 4-72 |
| Troubleshooting the shot pin cylinder<br>and clamp cylinder .....        | 4-74 |
| Operation .....                                                          | 4-74 |
| System test .....                                                        | 4-74 |
| Troubleshooting the link tilt cylinders .....                            | 4-78 |
| Operation .....                                                          | 4-78 |
| System test .....                                                        | 4-78 |
| Troubleshooting the counterbalance system .....                          | 4-82 |
| Counterbalance testing .....                                             | 4-82 |
| Stand jump testing .....                                                 | 4-84 |
| Troubleshooting the hydraulic power unit and reservoir .....             | 4-86 |
| Operation .....                                                          | 4-86 |
| System test .....                                                        | 4-86 |
| Troubleshooting the gearbox lubrication<br>hydraulic system .....        | 4-89 |
| Operation .....                                                          | 4-89 |
| System test .....                                                        | 4-89 |

## Chapter 7 Disassembly and assembly

|                                                                      |       |
|----------------------------------------------------------------------|-------|
| Precautions .....                                                    | 4-93  |
| PH-50 Pipehandler .....                                              | 4-94  |
| Disassembling the PH-50 Pipehandler .....                            | 4-94  |
| Assembling the PH-50 Pipehandler .....                               | 4-97  |
| Rotating link adapter/load stem .....                                | 4-99  |
| Disassembling the rotating link adapter/load stem ...                | 4-99  |
| Assembling the rotating link adapter/load stem .....                 | 4-101 |
| Transmission/motor housing .....                                     | 4-105 |
| Removing the transmission/motor housing .....                        | 4-105 |
| Installing the transmission/motor housing .....                      | 4-105 |
| Disassembling the transmission/motor housing .....                   | 4-106 |
| Removing the bonnet and wash pipe .....                              | 4-106 |
| Removing the upper bearing retainer plate .....                      | 4-108 |
| Removing the AC drilling motors<br>and hydraulic oil reservoir ..... | 4-110 |
| Removing transmission components .....                               | 4-110 |
| Assembling the transmission/motor housing .....                      | 4-114 |
| Assembling the main body .....                                       | 4-114 |
| Assembling the main shaft .....                                      | 4-118 |
| Assembling the gears to the main body .....                          | 4-120 |
| Assembling the cover .....                                           | 4-122 |
| Assembling the cover to the main body .....                          | 4-122 |
| Installing the AC drilling motors .....                              | 4-124 |
| Installing the upper bearing retainer plate .....                    | 4-126 |
| Installing the bonnet and wash pipe .....                            | 4-128 |
| Checking the gear train backlash .....                               | 4-129 |
| Shot pin disassembly/assembly .....                                  | 4-130 |
| AC drilling motor disassembly/assembly .....                         | 4-132 |
| AC drilling motor disassembly .....                                  | 4-132 |
| AC drilling motor assembly .....                                     | 4-134 |
| Replacing the safety wiring .....                                    | 4-136 |
| Safety wiring tips .....                                             | 4-138 |

# Book 5 – Parts List

---

## Illustrated parts lists

|                                                          |       |
|----------------------------------------------------------|-------|
| Figure 5-1. TDS-9S Drilling unit assembly .....          | 5-2   |
| Figure 5-2. General arrangement .....                    | 5-6   |
| Figure 5-3. Shipping package .....                       | 5-10  |
| Figure 5-4. Link/link tilt/elevator .....                | 5-12  |
| Figure 5-5. Service loop .....                           | 5-16  |
| Figure 5-6. Driller's console .....                      | 5-18  |
| Figure 5-7. Guide beams (roller) .....                   | 5-22  |
| Figure 5-8. Guide beams (slider) .....                   | 5-24  |
| Figure 5-9. Universal tiebacks .....                     | 5-26  |
| Figure 5-10. Tiebacks (sliding) .....                    | 5-28  |
| Figure 5-11. Link tilt hydraulic cylinder assembly ..... | 5-30  |
| Figure 5-12. Intermediate tieback kit .....              | 5-34  |
| Figure 5-13. Traveling equipment attachment kit .....    | 5-36  |
| Figure 5-14. Bail assembly .....                         | 5-38  |
| Figure 5-15. Counterbalance assembly .....               | 5-40  |
| Figure 5-16. Motor guards .....                          | 5-44  |
| Figure 5-17. S-pipe .....                                | 5-46  |
| Figure 5-18. S-pipe (Hercules) .....                     | 5-48  |
| Figure 5-19. Torque arrestor assembly .....              | 5-50  |
| Figure 5-20. IBOP actuator .....                         | 5-54  |
| Figure 5-21. IBOP pipehandler .....                      | 5-56  |
| Figure 5-22. Bonnet/bearing retainer assembly .....      | 5-60  |
| Figure 5-23. Transmission/gearbox assembly .....         | 5-62  |
| Figure 5-24. Rotating link adapter (400 Ton) .....       | 5-66  |
| Figure 5-25. Rotating link adapter (350 Ton) .....       | 5-70  |
| Figure 5-26. Shot pin assembly .....                     | 5-74  |
| Figure 5-27. AC motor brake assembly, left .....         | 5-78  |
| Figure 5-28. AC motor brake assembly, right .....        | 5-82  |
| Figure 5-29. AC motor assembly .....                     | 5-86  |
| Figure 5-30. Gearbox lube pump assembly .....            | 5-88  |
| Figure 5-31. Carriage/accumulator (roll) .....           | 5-92  |
| Figure 5-32. Carriage assembly, right (roller) .....     | 5-94  |
| Figure 5-33. Carriage assembly, left (roller) .....      | 5-96  |
| Figure 5-34. Carriage/accumulator (skid) .....           | 5-98  |
| Figure 5-35. Carriage assembly, right (skid) .....       | 5-100 |
| Figure 5-36. Carriage assembly, left (skid) .....        | 5-102 |

March 9, 1998



---

**TDS-9S**

**Top Drive  
Drilling  
System**

**Description**

---

March 9, 1998

# Contents

## Preface/Manual conventions

|                              |     |
|------------------------------|-----|
| Safety information .....     | 1-5 |
| Directional references ..... | 1-6 |
| Manual layout .....          | 1-6 |

## Chapter 1 Overview

|                    |     |
|--------------------|-----|
| Introduction ..... | 1-7 |
|--------------------|-----|

## Chapter 2 Major component description

|                                                                     |      |
|---------------------------------------------------------------------|------|
| Introduction .....                                                  | 1-9  |
| AC drilling motors .....                                            | 1-10 |
| Motor cooling system .....                                          | 1-14 |
| Transmission/motor housing (main body)<br>and swivel assembly ..... | 1-16 |
| Counterbalance system .....                                         | 1-18 |
| Carriage and guide beam .....                                       | 1-20 |
| Hydraulic control system .....                                      | 1-22 |
| PH-50 Pipehandler .....                                             | 1-25 |
| Rotating link adapter .....                                         | 1-26 |
| Torque back-up clamp .....                                          | 1-28 |
| Two-way link tilt .....                                             | 1-29 |
| Internal Blowout Prevention (IBOP) .....                            | 1-30 |
| Drill pipe elevator .....                                           | 1-31 |
| Driller's console .....                                             | 1-32 |
| Throttle .....                                                      | 1-32 |
| Torque limit potentiometer .....                                    | 1-32 |
| Makeup limit potentiometer .....                                    | 1-32 |
| Switches and buttons .....                                          | 1-33 |
| Indicator lights .....                                              | 1-33 |
| Service loop .....                                                  | 1-35 |
| Variable Frequency Inverter (VFI) .....                             | 1-36 |
| Rectifier/capacitor .....                                           | 1-36 |
| Power modules .....                                                 | 1-36 |
| Control sections .....                                              | 1-36 |

# Chapter 3 Specifications

- AC drilling motors ..... 1-39
- Variable Frequency Inverter (VFI) ..... 1-39
- Motor braking ..... 1-39
- Motor cooling system ..... 1-40
- Electrical service loop ..... 1-40
- Gearcase ..... 1-41
- Gearcase lubrication ..... 1-41
- Hydraulic system ..... 1-41
- System specifications ..... 1-41
- Diagrams ..... 1-42

## Manual conventions

### Safety information

---

Information pertaining to possible personnel injury and equipment damage appears throughout this manual and is formatted to draw the reader's attention to important information, a warning, or a caution note. See the examples below and pay close attention to these important advisories.



Indicates advisories for operational or servicing procedures involving little or no risk of personnel injury and equipment damage.



*Indicates advisories involving a risk of equipment damage.*



***Indicates advisories involving a definite risk of injury to rig personnel.***

Avoid personnel injury and equipment damage by reading this manual and related documents before operating, inspecting, or servicing the equipment.

## Directional references

---

References to the right or left and front or back of components described in this manual assume the perspective of the top drive drilling system (TDS-9S), standing behind the TDS-9S as it faces well center.

## Manual layout

---

This binder contains several separate books that you can remove individually for convenience.

# Chapter 1

## Overview

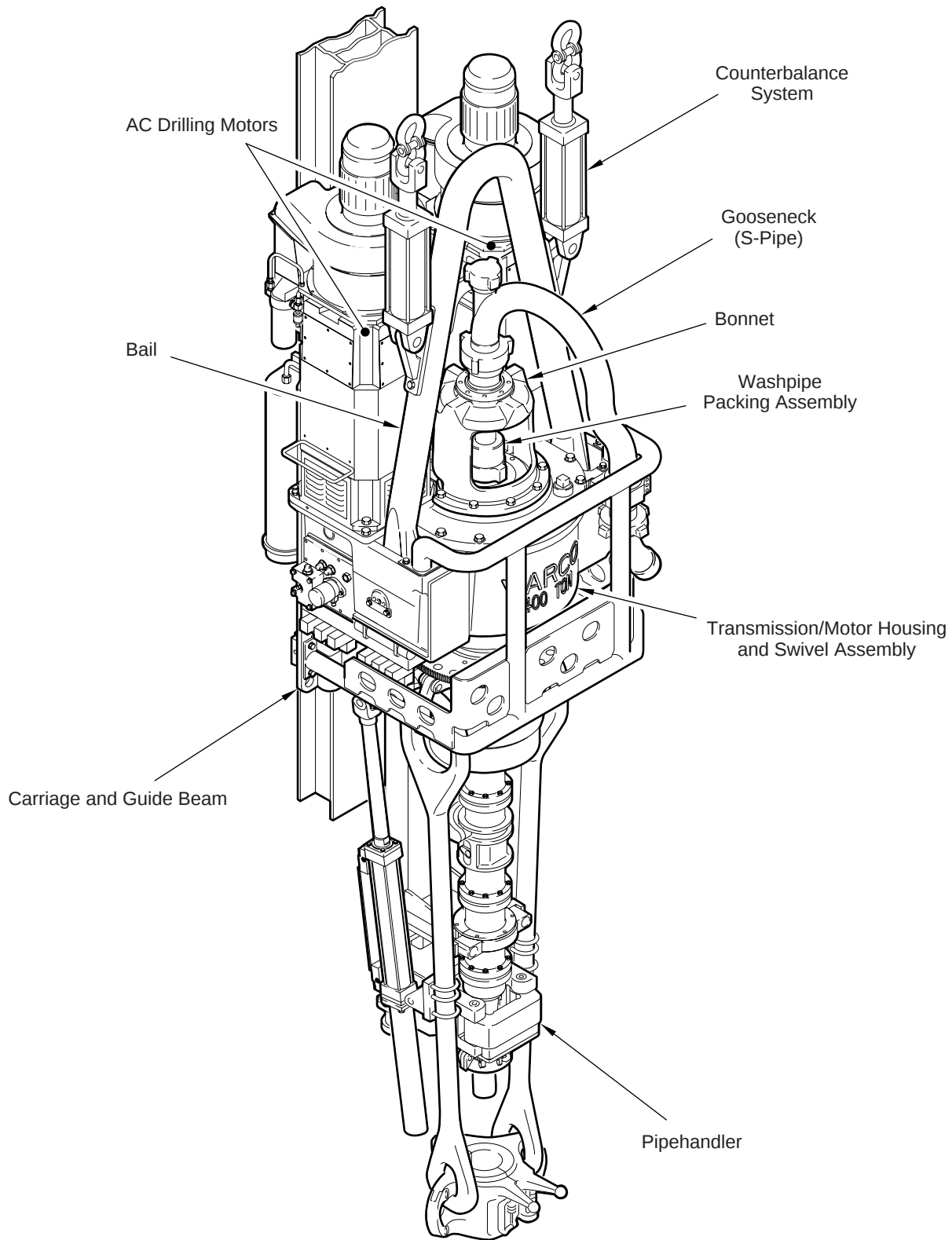
### Introduction

---

This book contains a description, and theory of operation, of the major components that make up the TDS-9S Top Drive Drilling System.

The TDS-9S is a highly portable and compact top drive drilling system. Two 350 horsepower variable frequency AC drilling motors provide drilling power for the TDS-9S, while an onboard hydraulic system powers all ancillary functions, eliminating the need for a stand alone hydraulic power unit and fluid service loops.

The illustration on the following page (Figure 1-1) shows the nine major subassemblies that make up the TDS-9S.



**Figure 1-1. Typical TDS-9S**



# Chapter 2

## Major component description

### Introduction

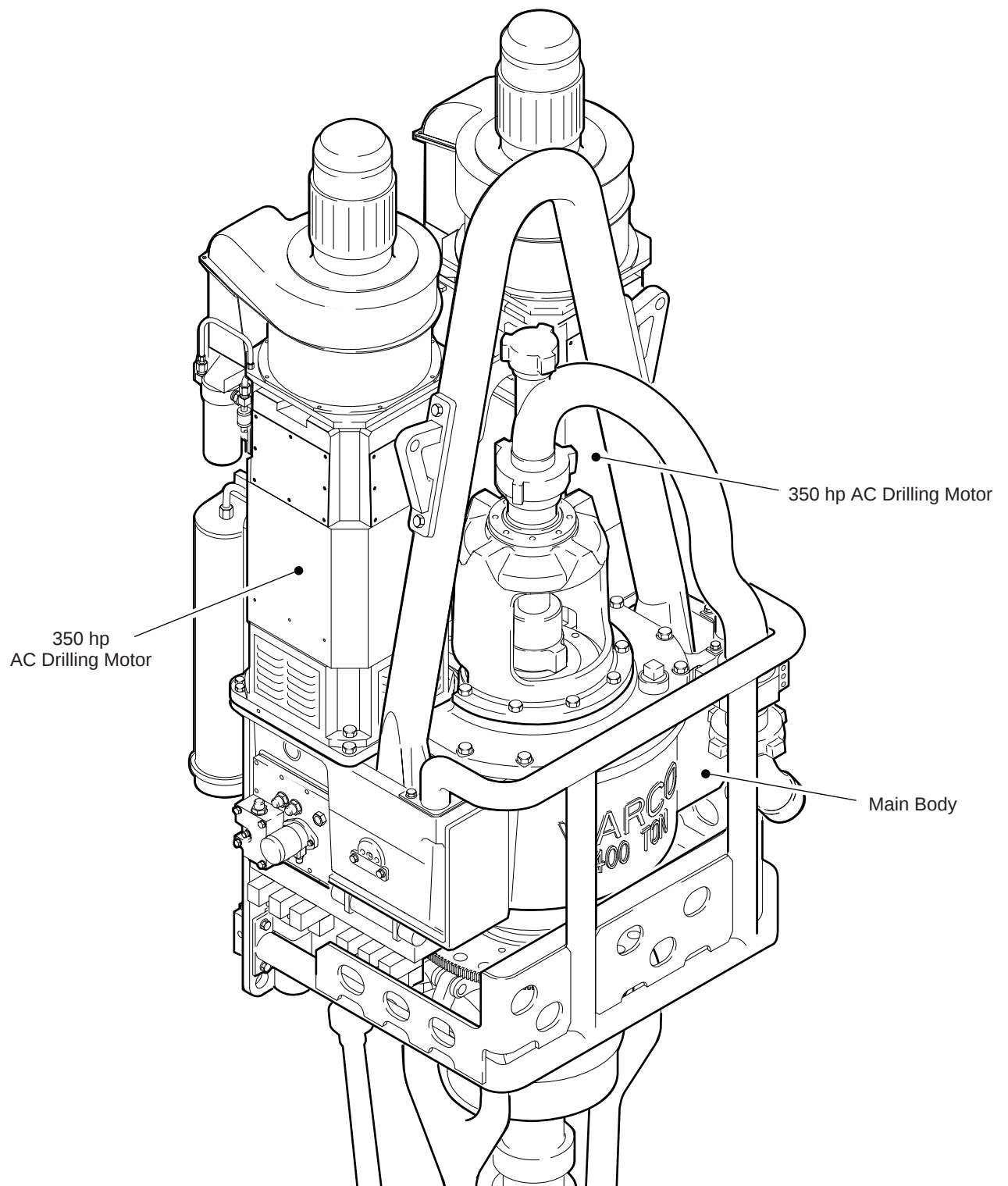
---

The following describes the TDS-9S component parts, and defines terms used throughout this manual.

# AC drilling motors

---

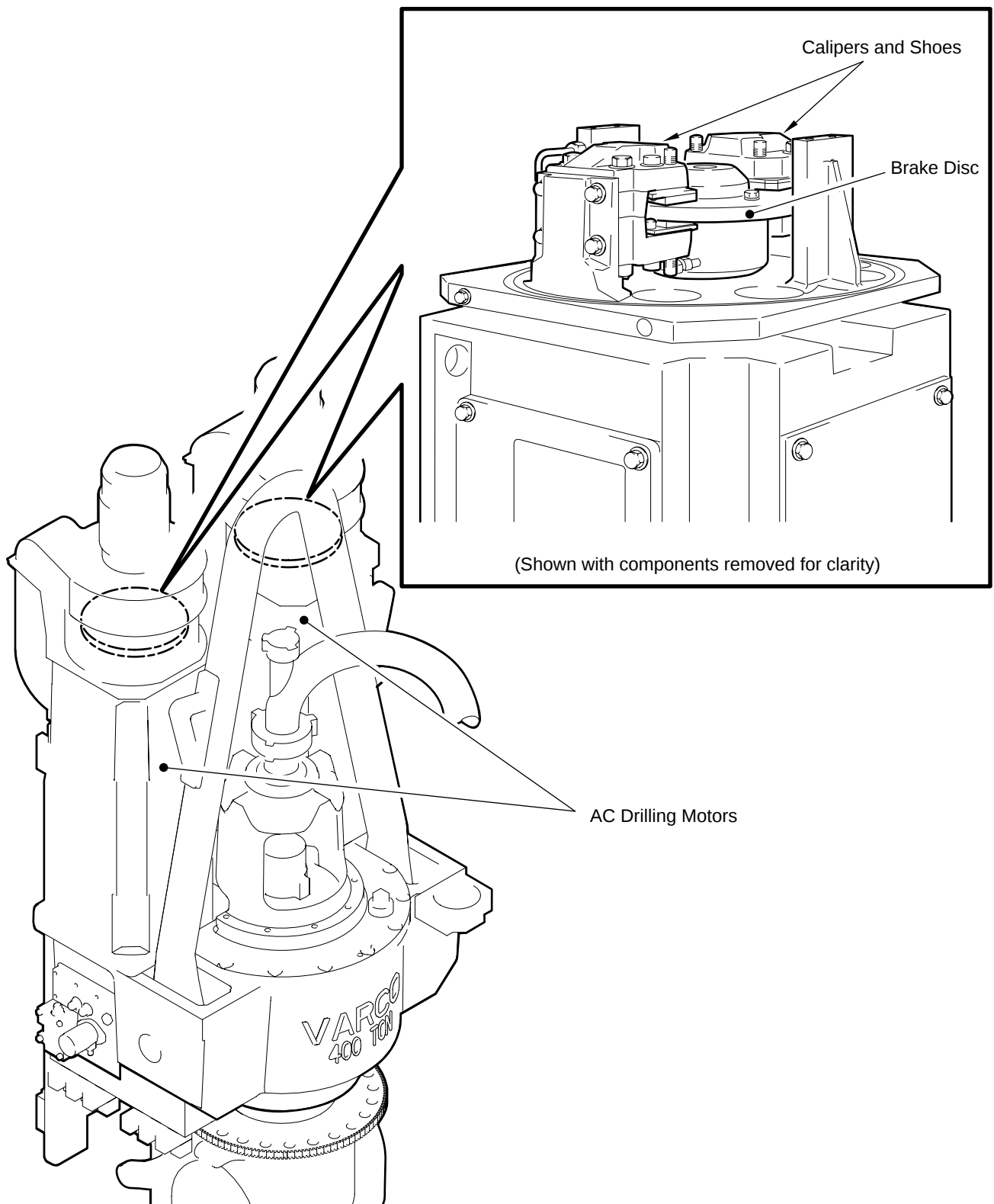
The TDS-9S uses two 350 hp AC motors mounted vertically side by side on top of the main body to power the TDS-9S (Figure 1-2).



**Figure 1-2. AC drilling motors**

A modified D-face attaches the drilling motors to the main body. This mounting method allows installation of the drilling motors without shimming or special alignment. Each motor has a double ended shaft with a drive pinion mounted on the lower end and a disc brake rotor mounted on the upper end. Two hydraulic caliper disc brakes, mounted to the top end of each motor, hold torque in the drill string and assist in positioning during directional work (Figure 1-3). An electrical solenoid valve remotely operates the hydraulic caliper disc brakes.

The AC drilling motors are an open-frame type, meaning that the cooling air passes through the inside of the motor. The drilling motors, manufactured specifically for top drive applications, have internal temperature sensors, vacuum varnish impregnated windings, high capacity bearings, and tapered output shafts to improve serviceability of the pinion gear and brake hubs.

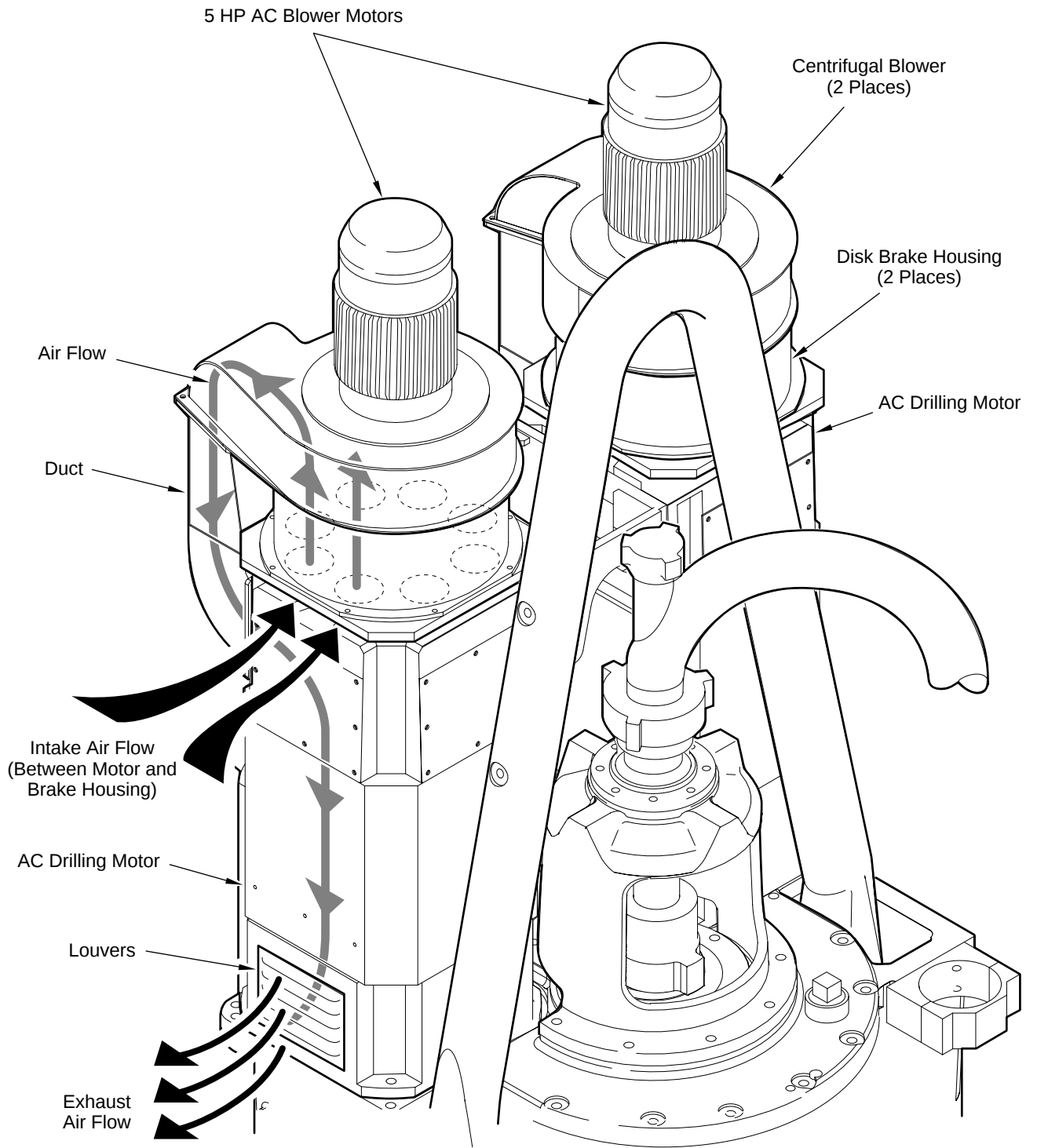


**Figure 1-3. AC drilling motor brakes**

# Motor cooling system

---

The motor cooling system on the TDS-9S is a local intake pressure blower type. It consists of two 5 hp AC motors integrally mounted on top of each AC drilling motor (Figure 1-4). Air is drawn in from the combination brake cover/air intake and delivered through rigid ducting to an opening in the top of each motor. The cooling air then passes through the inside of the open-frame type AC drilling motors and exits out of louver openings near the bottom of the motors.



**Figure 1-4. Motor cooling system**

# Transmission/motor housing (main body) and swivel assembly

---

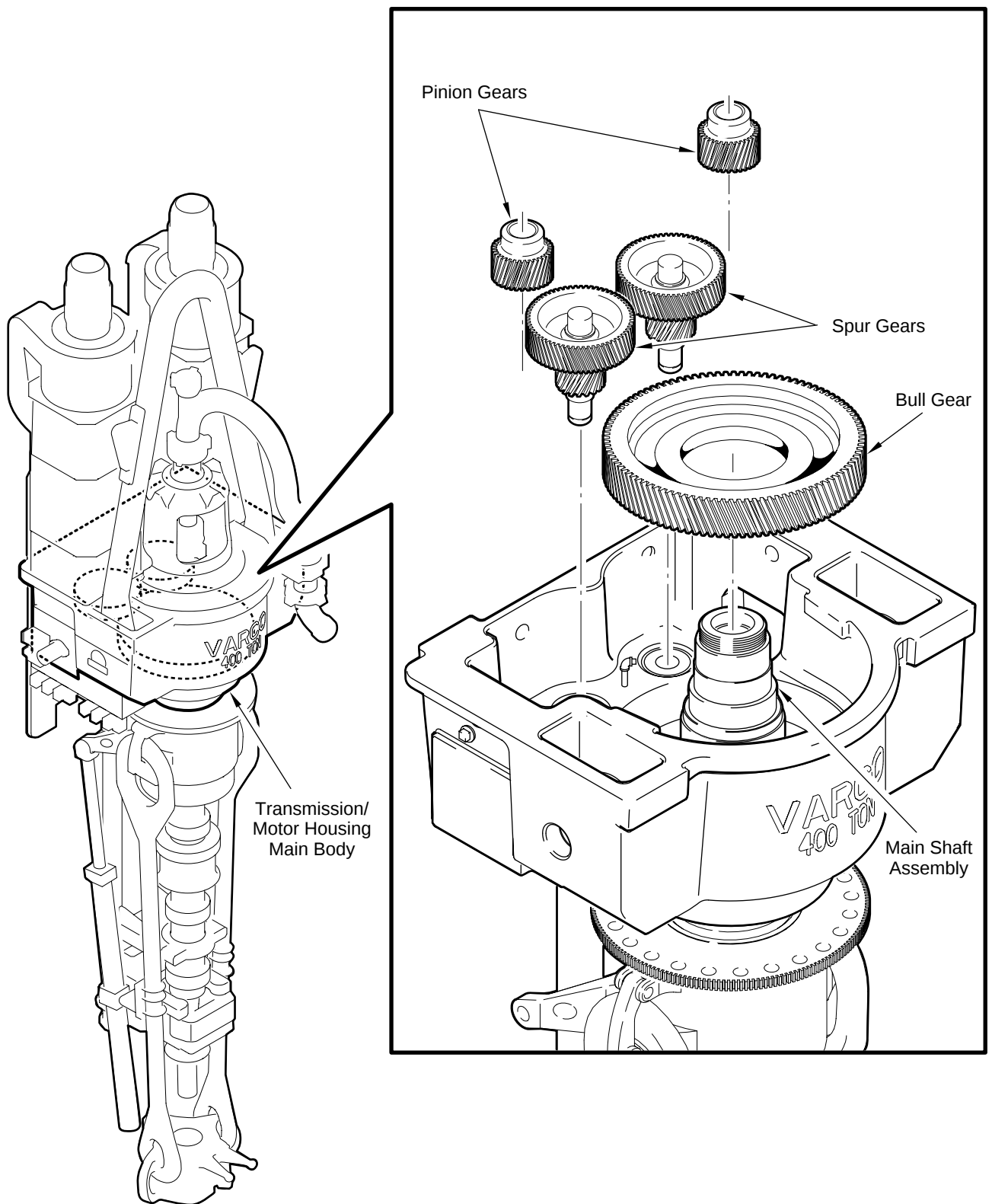
The transmission/motor housing and swivel assembly transfers the power produced by the AC drilling motors to the drill string (Figure 1-5). Inside the transmission/motor housing main body is a single-speed double-reduction gear system that provides a 10.5:1 ratio from the motors to the main shaft.

The main body of the motor housing provides a sealed oil lubrication reservoir for the transmission gears and bearings. Bearings and gears are force fed by an oil pump that is integral with the main body. A low speed hydraulic motor drives the oil pump. The filtered lubrication oil constantly circulates through the main thrust bearing, take-up bearing, lower radial and compound gear bearings and over the gear meshes.

An industry standard wash pipe packing box assembly is located between the main shaft/swivel stem and the S-pipe weldment. The bonnet supports the S-pipe weldment.

The forged alloy steel bail swings forward for attaching to standard rotary drilling hooks. The bail is fitted with bronze bushings that are grease lubricated.





**Figure 1-5. Transmission/motor housing (main body) and swivel assembly**

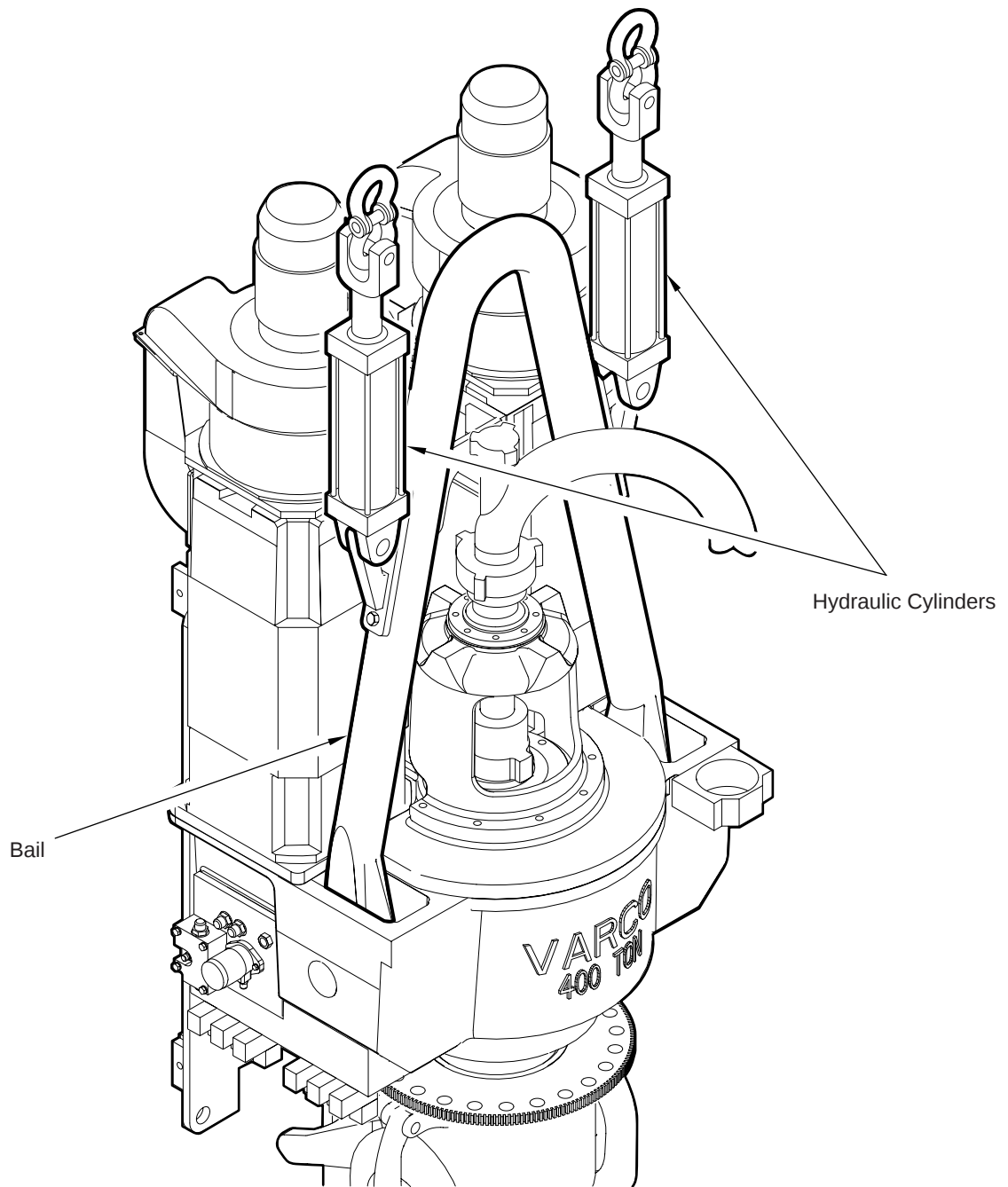
# Counterbalance system

---

The counterbalance system includes two hydraulic cylinders connected between the bail and the hook (Figure 1-6). When the system is activated, the two cylinders support most of the weight of the TDS-9S. This system protects tool joint threads by taking much of the weight off the drill pipe while making or breaking connections.

An optional new feature for the TDS-9S is called STAND JUMP. It consists of a switch at the driller's console allowing you to change the mode of operation of the counterbalance cylinders from DRILL, which is a standard counterbalance condition, to STAND JUMP. The optional STAND JUMP feature allows the cylinders to lift the weight of the top drive off the drill string while breaking out a connection. This eases the stress on the threads and avoids damage. The cylinders lift the swivel bail off its resting point on the hook.

The two hydraulic cylinders are connected to a hydro-pneumatic accumulator located on the main body. A manual valve can extend the cylinders to assist during rig-up. The accumulator is charged with hydraulic fluid and maintained at a predetermined pressure setting by the counterbalance circuit in the hydraulic control manifold, located on the main body. The hydraulic manifold controls all hydraulic power to the TDS-9S.



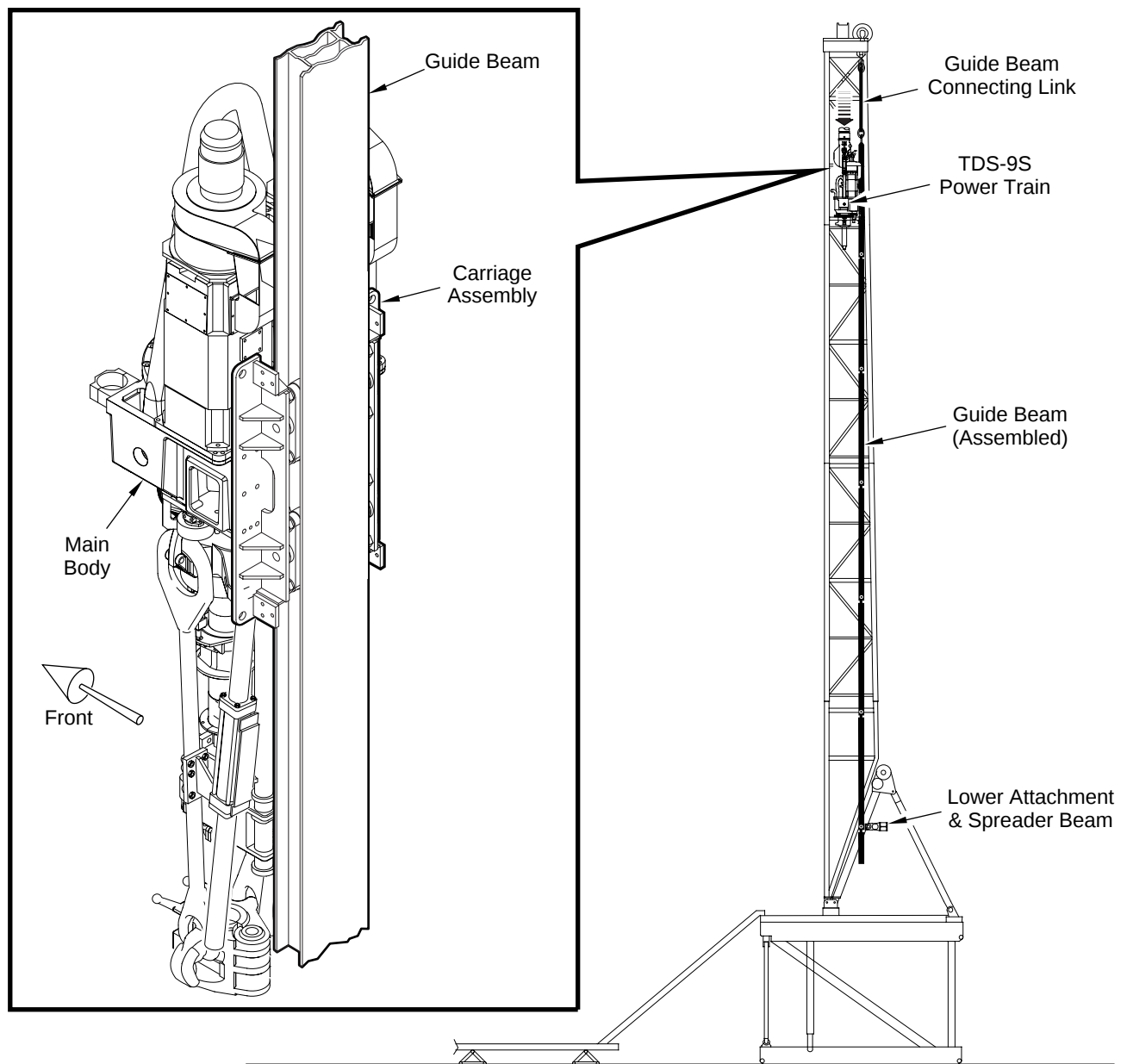
**Figure 1-6. Counterbalance system**

# Carriage and guide beam

---

The TDS-9S travels vertically along a guide beam on a carriage attached to the main body (Figure 1-7). The guide beam hangs from the crown block and extends to within seven feet of the drill floor. The guide beam attaches to a torque reaction spreader beam mounted across the lower section of the mast/derrick, approximately 10-15 feet above the drill floor.

The guide beam counters the drilling torque produced as the transmission turns the drill string. The guide beam comes in sections and requires brackets for mounting to the crown. The guide beam sections are pinned together in such a way that they hinge and can be assembled one section at a time, at the drill floor, and raised to the crown attachment using the TDS-9S.



**Figure 1-7. Carriage and guide beam**

# Hydraulic control system

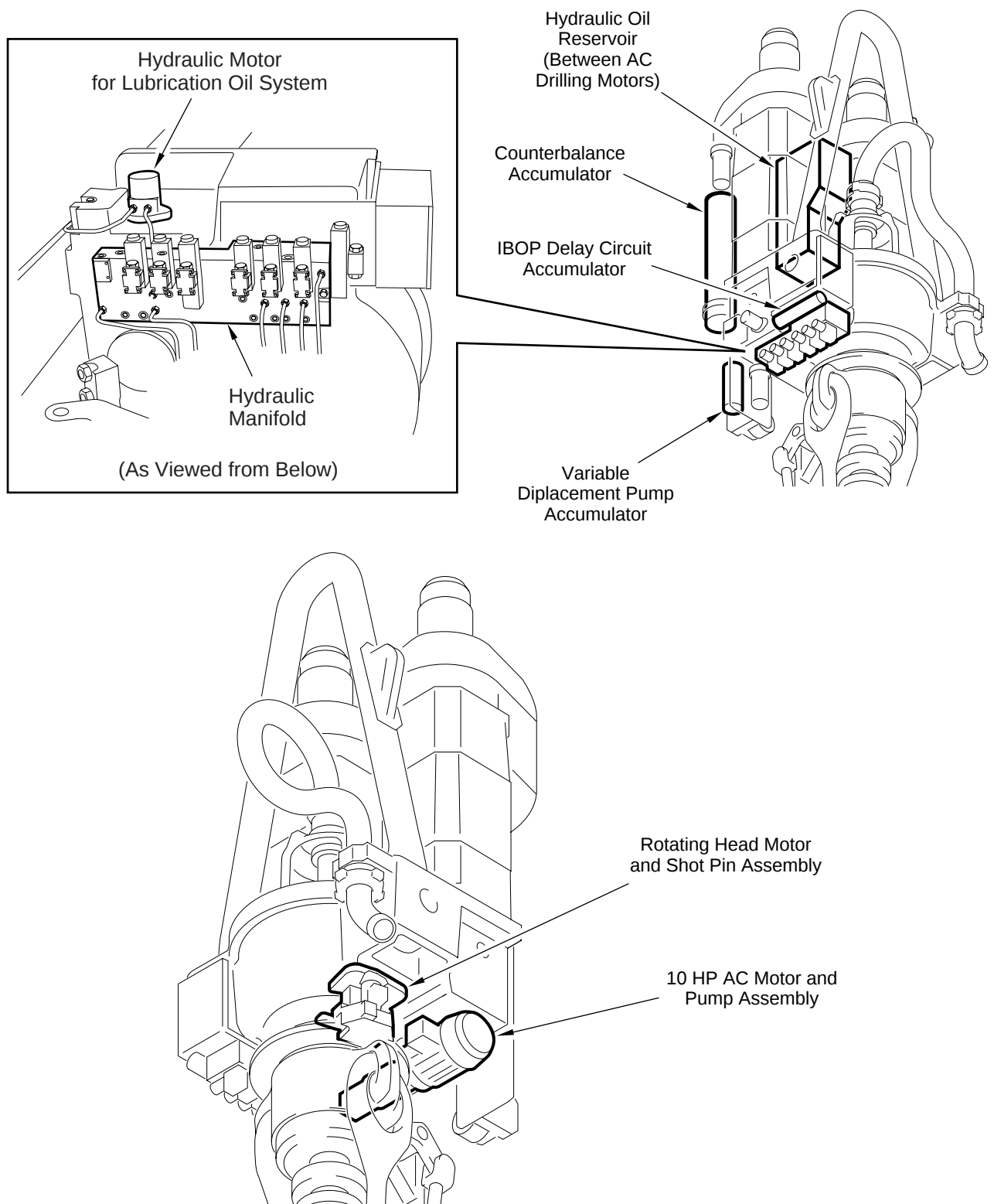
---

The hydraulic control system (Figures 8 and 9) is a completely self-contained, onboard system. A 10 hp, 1,800 rpm, AC motor, drives two hydraulic pumps and powers the hydraulic system. A fixed displacement pump drives the lube oil system motor. A variable displacement pump provides hydraulic power for the AC drilling motor brakes, powered rotating head, remote actuated IBOP, pipe backup clamp cylinder, link tilt, and counterbalance system.

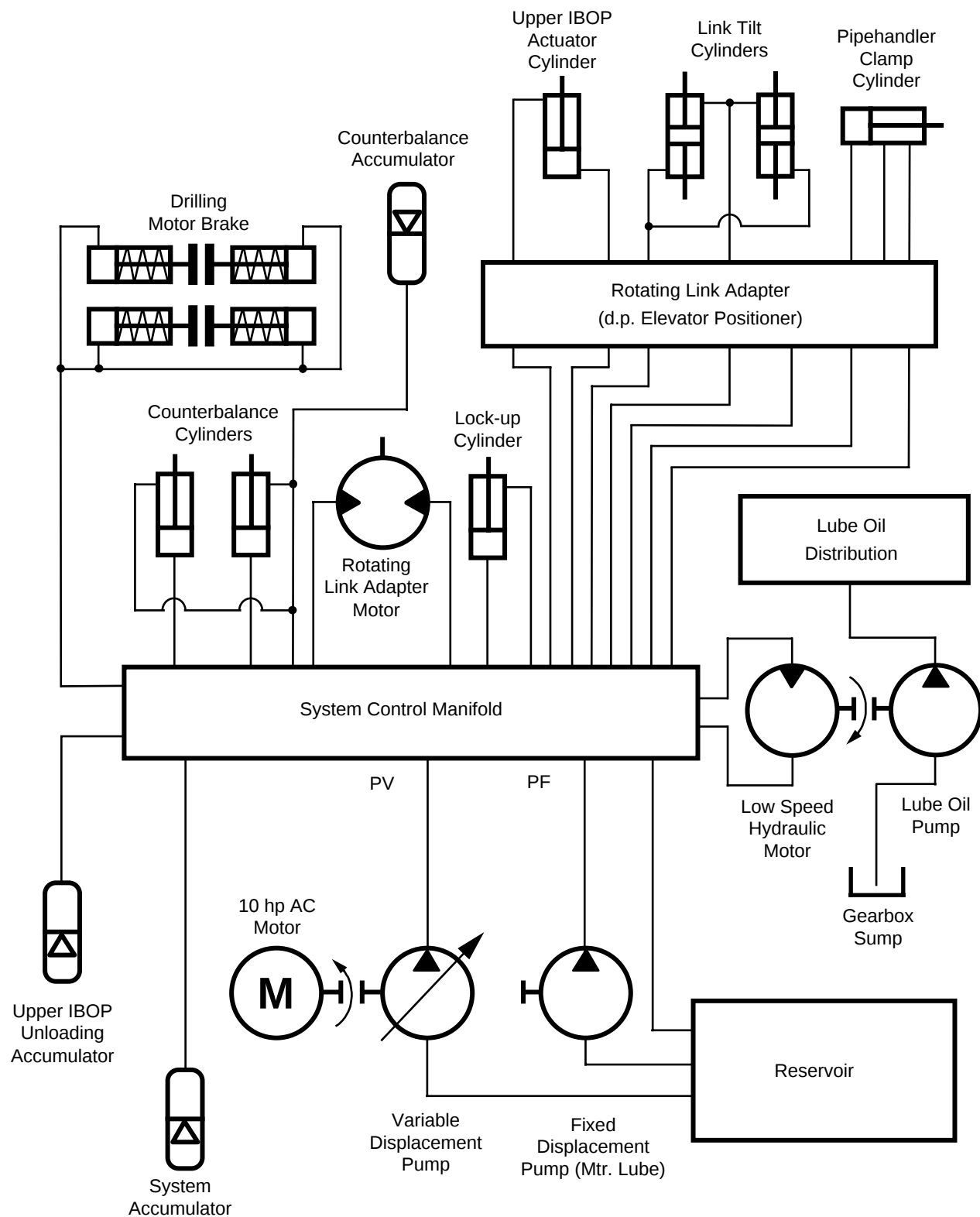
The hydraulic manifold attaches to the main body and contains solenoid, pressure and flow control valves.

A sealed stainless steel reservoir supplies hydraulic oil, *eliminating the need for draining and refilling during normal rig moves*. The reservoir is mounted between the two AC drilling motors and is equipped with strainers and oil level sight gauge.

Three hydro-pneumatic accumulators are located on the main body. The counterbalance system uses the largest accumulator. The medium size accumulator unloads the variable displacement pump and the smallest accumulator activates the delay circuit on the IBOP actuator.



**Figure 1-8. Hydraulic control system**



**Figure 1-9. Hydraulic system schematic**

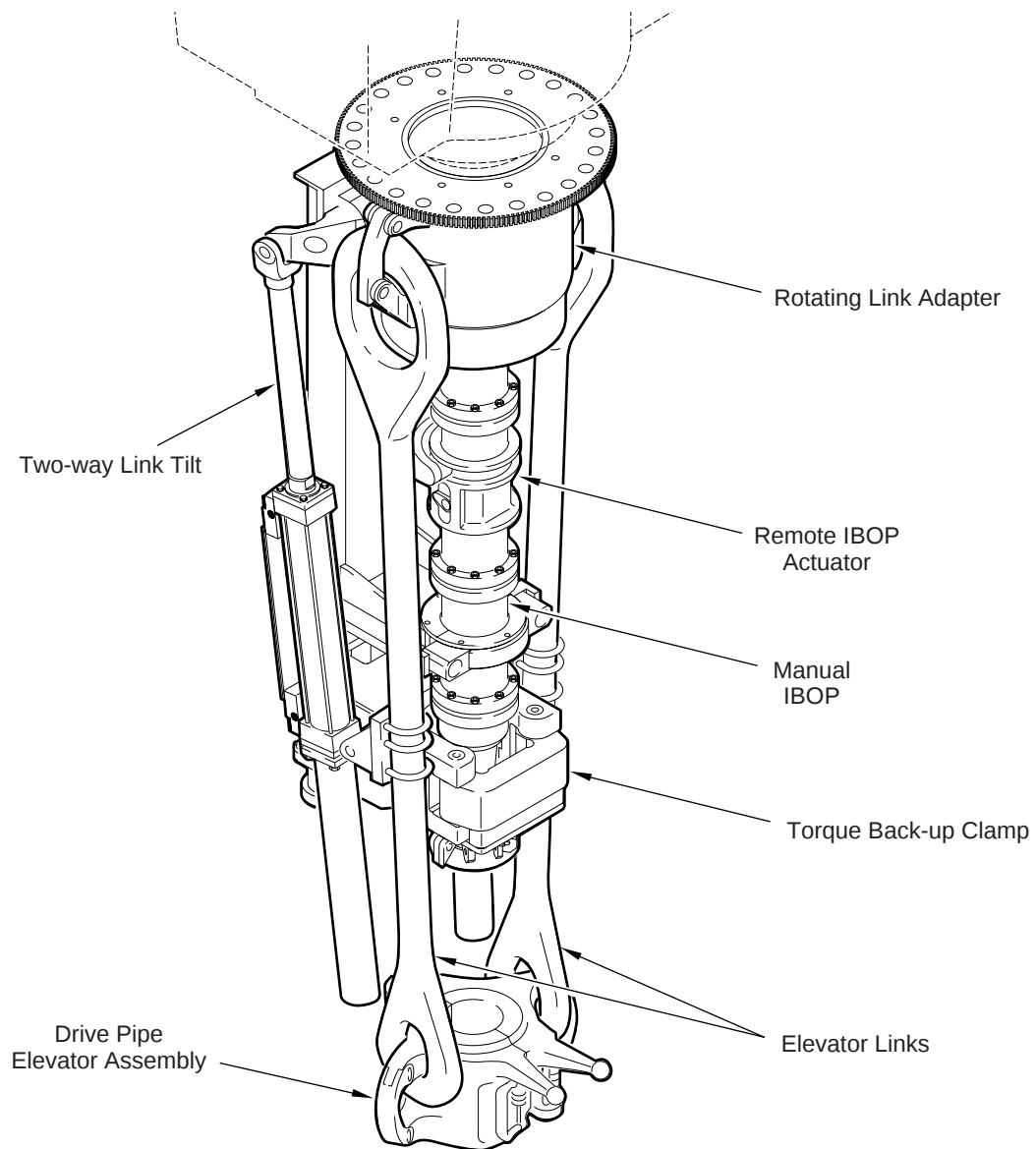


# PH-50 Pipehandler

---

The PH-50 Pipehandler consists of the following major components (Figure 1-10):

- ❑ Rotating link adapter
- ❑ Torque back-up clamp
- ❑ Two-way link tilt
- ❑ Internal blowout prevention (IBOP) valves
- ❑ Elevator links and drill pipe elevator



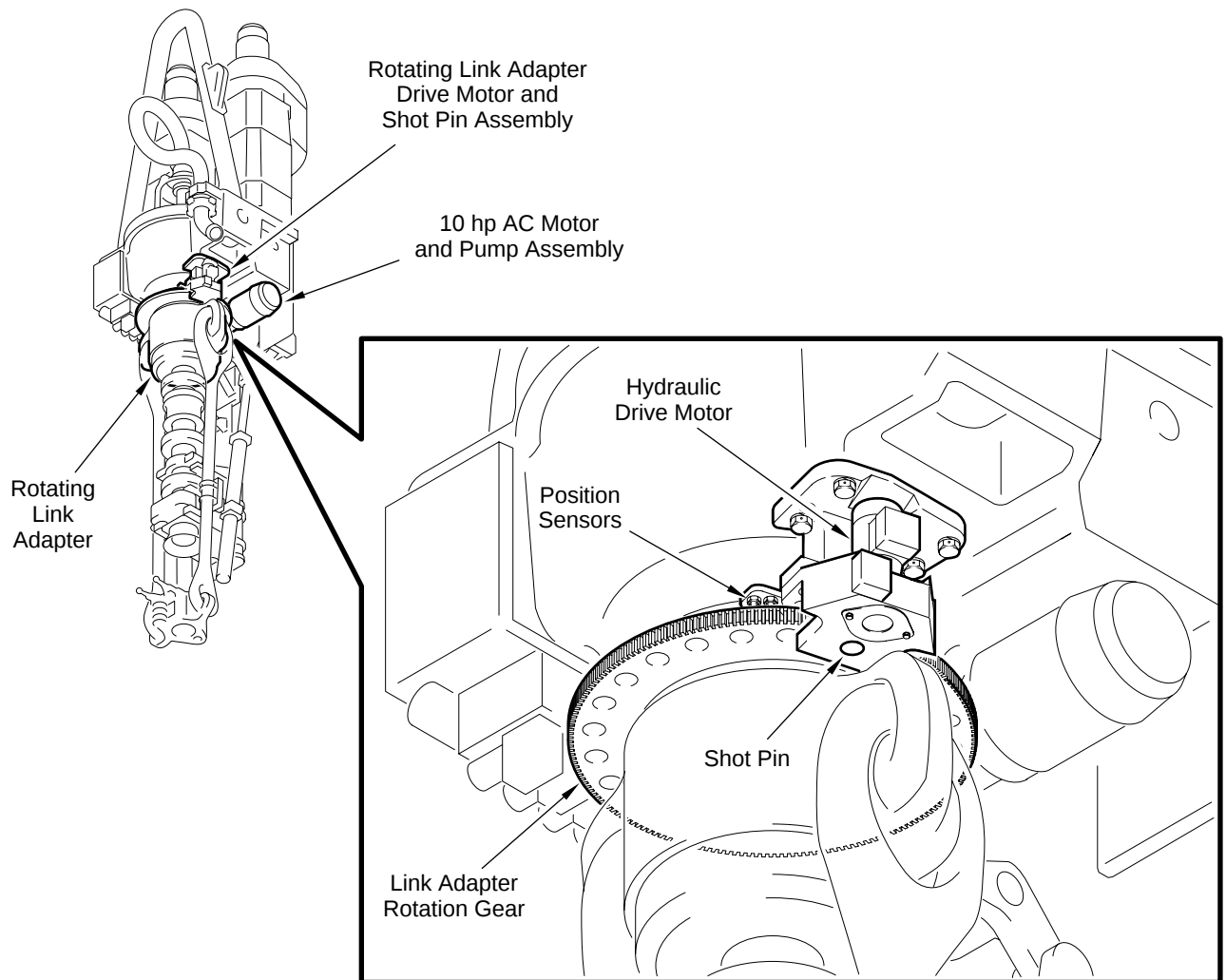
**Figure 1-10. PH-50 Pipehandler**

## Rotating link adapter

The powered rotating link adapter, located at the top of the pipehandler, is a slip ring assembly. It allows the hydraulic lines to remain connected as the pipehandler rotates with the drill stem components while tripping out or positioning the link tilt. The rotating link adapter also provides an attachment for the link tilt, pipe backup clamp cylinder, and remote IBOP actuator assembly.

Grooves in the rotating link adapter align with radial holes in the load stem, allowing hydraulic fluid to flow between the rotating link adapter and the load stem as they rotate. The radial passages at the upper end of the load stem intersect with each hose attachment that runs to the hydraulic manifold. The radial passages in the lower end of the load stem intersect sealed grooves in the rotating link adapter that, in turn, connect with hose attachments that run to all the actuators on the pipehandler.

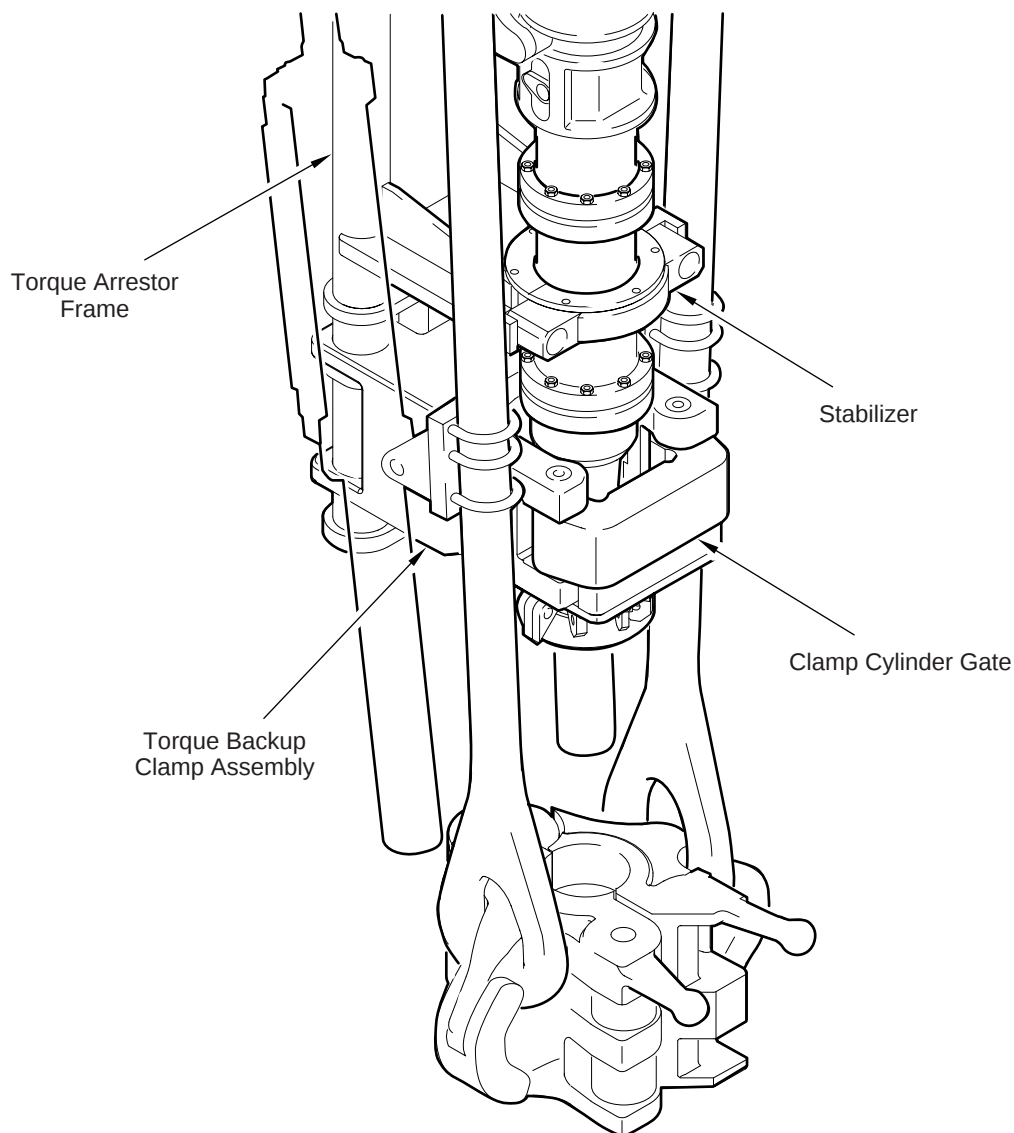
The rotating link adapter is powered in either direction by a hydraulic drive motor (Figure 1-11). An electric solenoid valve operates the rotating link adapter hydraulic motor.



**Figure 1-11. Hydraulic drive motor**

## Torque back-up clamp

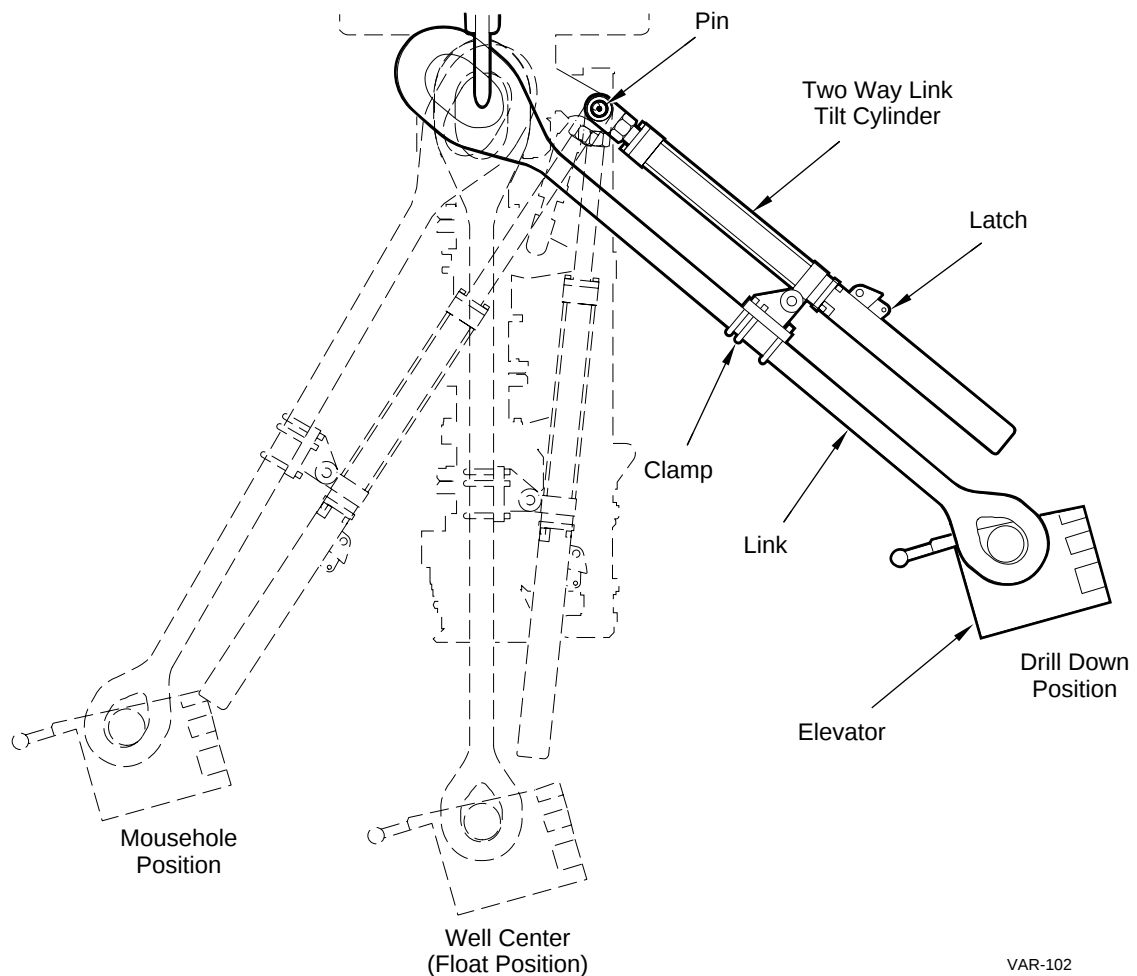
The torque back-up clamp (Figure 1-12) is supported by a torque arrestor frame that hangs from the rotating link adapter. The backup clamp is located below the lower shoulder of the saver sub. It consists of a pair of gripping jaws with die inserts and a clamping cylinder for gripping the box end of the tool joint when connected to the saver sub. The backup clamp body is attached to the torque arrestor frame in such a way that it can float up or down to allow for thread engagement and counter backup torque while making and breaking connections.



**Figure 1-12. PH-50 Torque wrench**

## Two-way link tilt

The two-way link tilt (Figure 1-13) cylinder assemblies consist of the cylinder rods pinned to the rotating link adapter and the cylinder bodies pinned to the links through a set of clamps. Pressurizing the cylinder assemblies by operating the switch on the driller's console extends the drill pipe elevator to the mouse hole or the drill down position. A float position allows the links to return to well center. The latch on the cylinder assembly limits the travel of the elevator to the derrick man position. Releasing the latch by pulling a cable allows the elevator to travel to the mousehole position.



VAR-102

**Figure 1-13. Two-way link tilt**

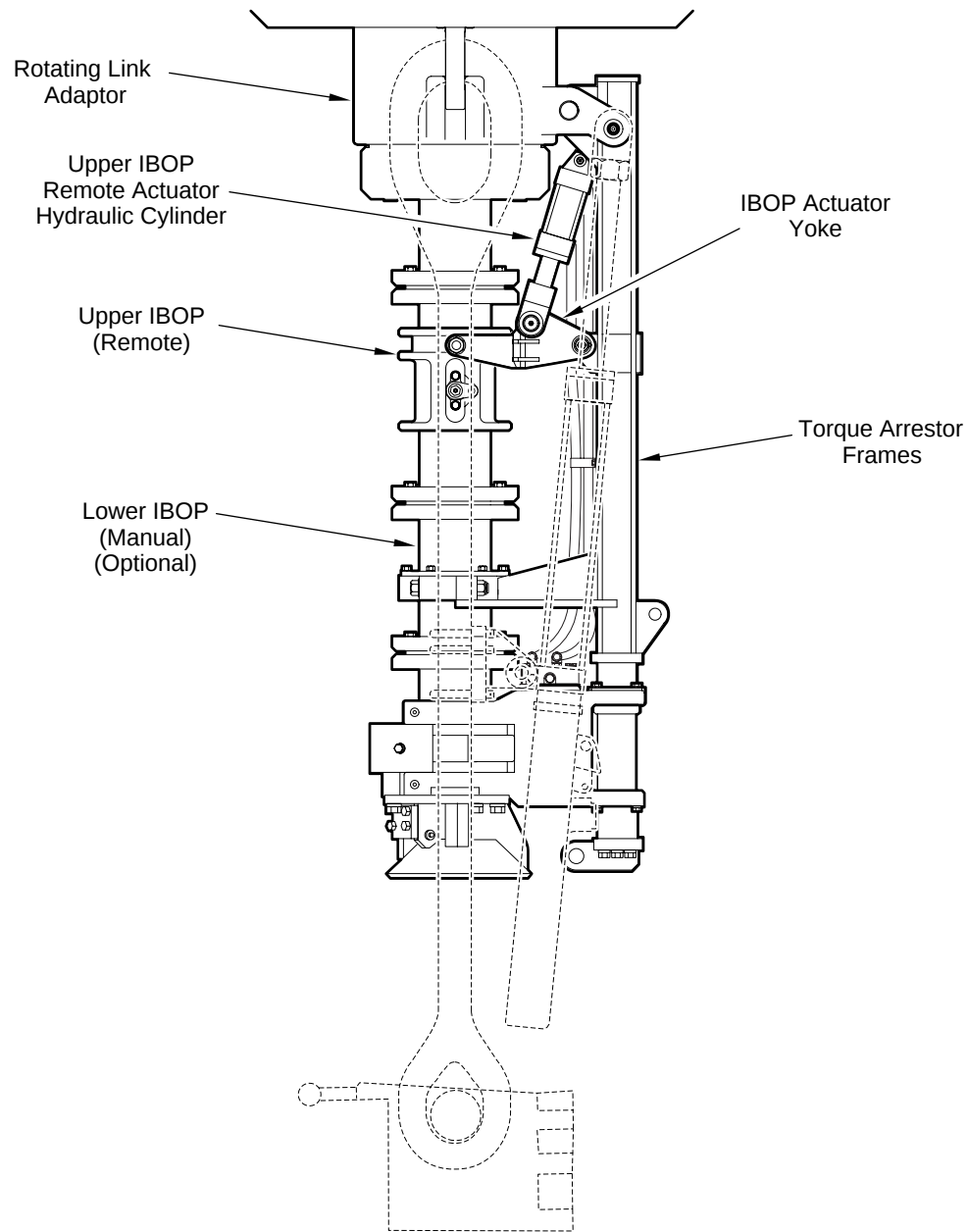
## Internal Blowout Prevention (IBOP)

The Internal Blowout Prevention (IBOP) (Figure 1-14) control valve contained in the pipehandler is a ball type, full size, internal opening safety valve. A second manually operated lower valve (optional) can be utilized to assist in well control. Both valves have 6 5/8 in. regular RH connections and 15,000 psi pressure ratings.

The remotely controlled upper IBOP valve is opened and closed by a yoke and a hydraulic cylinder that is controlled from the driller's console using an electric solenoid valve. A shell housing rotates with the valve body and moves up and down to drive a small crank arm on each side of the valve stem. The housing is actuated by a cylinder through a non-rotating actuator ring. The hydraulic cylinder is attached to the torque arrestor frame.

The optional lower valve is the same type as the upper except it must be manually opened and closed with a wrench. Both valves remain in the string at all times and are readily available by connecting the TDS-9S to the drill string. The lower valve can be broken-out from the upper valve using tongs after swinging the torque arrestor frame out of the way.

After breaking-out the lower valve, the TDS-9S can be hoisted away, allowing room to install the appropriate subs and valves for well control operations. After removing the lower valve from the upper valve on the TDS-9S using conventional rig tongs, the lower valve remains connected to the drill string for well control purposes. A crossover sub is included with the system to allow connection of the drill stem to the lower valve.



**Figure 1-14. Internal blowout prevention (IBOP)**

## Drill pipe elevator

A drill pipe elevator hangs from a pair of large eye links that attach the link adapter (Figure 1-10). Actuating the link tilt swings the elevator out to facilitate picking up pipe.

# Driller's console

---

The Varco supplied driller's console (Figure 1-15) is equipped with the following items to directly interface with the AC frequency drives:

- ☐ Throttle
- ☐ Torque limit potentiometer
- ☐ Makeup limit potentiometer
- ☐ Switches and buttons
- ☐ Indicator lights

## Throttle

The throttle uses a design similar to a standard throttle control supplied with Silicone Controlled Rectifier (SCR) systems. The handle includes integral stops to prevent damage.

## Torque limit potentiometer

The torque limit potentiometer is also similar to the design used on SCR systems. The maximum torque output of the drive is limited to the continuous torque rating of the drive and motors.

## Makeup limit potentiometer

The makeup limit potentiometer controls the makeup torque when the top drive is used to makeup connections using the drilling motor. This control allows the top drive to operate at the intermittent rating to make up drill pipe connections.



## Switches and buttons

Switches and buttons control the following:

- ☐ Drill, Spin, Torque mode select
- ☐ Link tilt
- ☐ AC drilling motor brakes
- ☐ Backup clamp
- ☐ Rotating link adapter
- ☐ Remote IBOP valve
- ☐ Drill pipe forward/reverse select
- ☐ Stand jump (optional)
- ☐ Emergency stop

The driller's console also includes a horn to warn of an alarm condition.

The driller's console, made from 300-series stainless steel, uses full size oil tight switches and indicators, and is designed for purging to meet hazardous area requirements. The console can be supplied with Pyle-National explosion-proof connectors, if requested.

## Indicator lights

Indicator lights show the following conditions:

- ☐ Oil pressure loss
- ☐ Drill motor overtemperature
- ☐ Blower loss
- ☐ IBOP closed
- ☐ Brake on
- ☐ Drive fault



# Service loop

---

The TDS-9S requires one electrical service loop and an electrical auxiliary encoder loop. The main loop consists of three power cables and one ground cable; and a composite cable that contains all of the conductors for the auxiliary AC motors, sensors, and actuator (solenoid) control. Attachment of the electrical loop is the same as other Varco top drives.

The encoder loop routes the drilling motor encoder signal to the Variable Frequency Inverter (VFI). No hydraulic service loop is required because of the onboard hydraulic system.

# Variable Frequency Inverter (VFI)

---

The frequency inverter used to operate the TDS-9S AC drilling motors consists of three major parts:

- ☐ Rectifier/capacitor
- ☐ Power modules
- ☐ Control sections

## Rectifier/capacitor

The rectifier/capacitor section converts incoming 3-phase AC power to DC and stores the DC power in capacitors for use by the power devices.

## Power modules

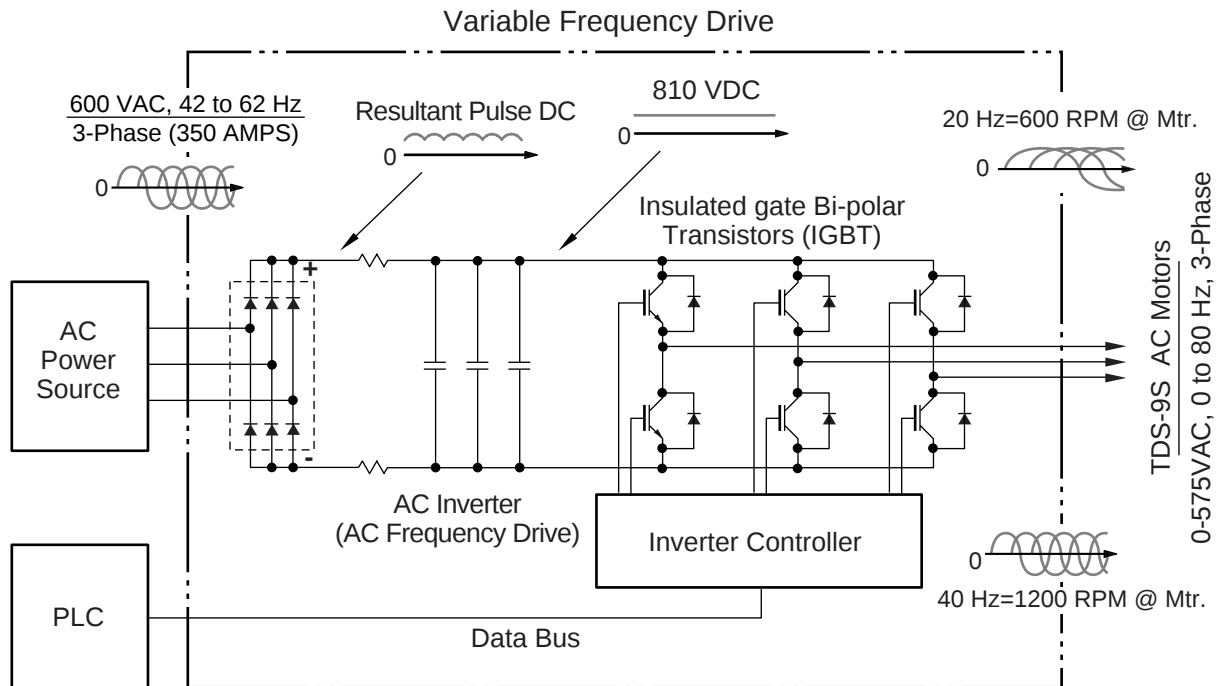
The power modules or inverters convert the DC power into a simulated AC signal using pulse-width-modulation (PWM).

## Control sections

The control section monitors the performance of the drilling motor, accepts throttle and torque limit signals from the driller, and controls the firing circuits of the power modules.

The driller controls the speed of the AC drilling motors with a hand throttle. The throttle varies the frequency and voltage to the motor. Since the drilling motor is frequency synchronous, the speed of the motor is proportional to the frequency (i.e., 20 Hz is 600 motor rpm, 40 Hz is 1,200 motor rpm). Because of the nature of AC motors, the voltage supplied to the motors varies with the frequency, and is stated as volts per Hertz.

The drive accepts DC voltage by bypassing the input rectifier circuit. The drive requires a DC voltage of 740 VDC  $\pm$  10%, 750 amperes continuous, and 1,110 amperes intermittent.



**Figure 1-16. Variable frequency AC drive schematic**

March 9, 1998

# Chapter 3

## Specifications

### AC drilling motors

See the *Reliance Electric Manual* in the *Vendor Documentation Package*.

### Variable Frequency Inverter (VFI)

See the *AC Motor Drive Service Manual* in the *Vendor Documentation Package*.

### Motor braking

|      |                               |
|------|-------------------------------|
| Type | Hydraulic caliper disc brakes |
|------|-------------------------------|

## Motor cooling system

|                          |                                   |
|--------------------------|-----------------------------------|
| Type                     | Local intake pressure blower      |
| Power                    | (2) 5 hp (3kW) AC motors          |
| Speed                    | 3,600 rpm                         |
| Voltage, freq. and phase | 575 V, 60Hz, 3ø                   |
| Full load current        | 5.5 A                             |
| Enclosure                | Explosion proof, Class 1, Group D |
| Insulation class         | F                                 |
| Mounting method          | C-Face                            |
| Hazardous area class     | Class 1, Div 1                    |
| Temp code                | T3C (160°C max.)                  |
| Ambient temp rating      | 40°C                              |
| Flow                     | 1,400 CFM per motor               |

## Electrical service loop

|                           |                                                                                                                  |
|---------------------------|------------------------------------------------------------------------------------------------------------------|
| Power cables              | Three 646 MCM,<br>2,000 Volt max.                                                                                |
| Auxiliary composite cable | Conductors (Qty/type/size):<br><br>26 SGL/14 AWG<br>4 SGL/8 AWG<br>2 triads, not shielded/14 AWG<br>3 TSP/14 AWG |
| Ground cable              | 2/0 conductor w/.030 thk<br>green TPR insulation                                                                 |



## Gearcase

|            |                                                 |
|------------|-------------------------------------------------|
| Type       | Single speed, double reduction spur gear system |
| Gear Ratio | 10.5:1 reduction                                |

## Gearcase lubrication

|                    |               |
|--------------------|---------------|
| Type               | Pressure feed |
| Reservoir capacity | 15 gal        |

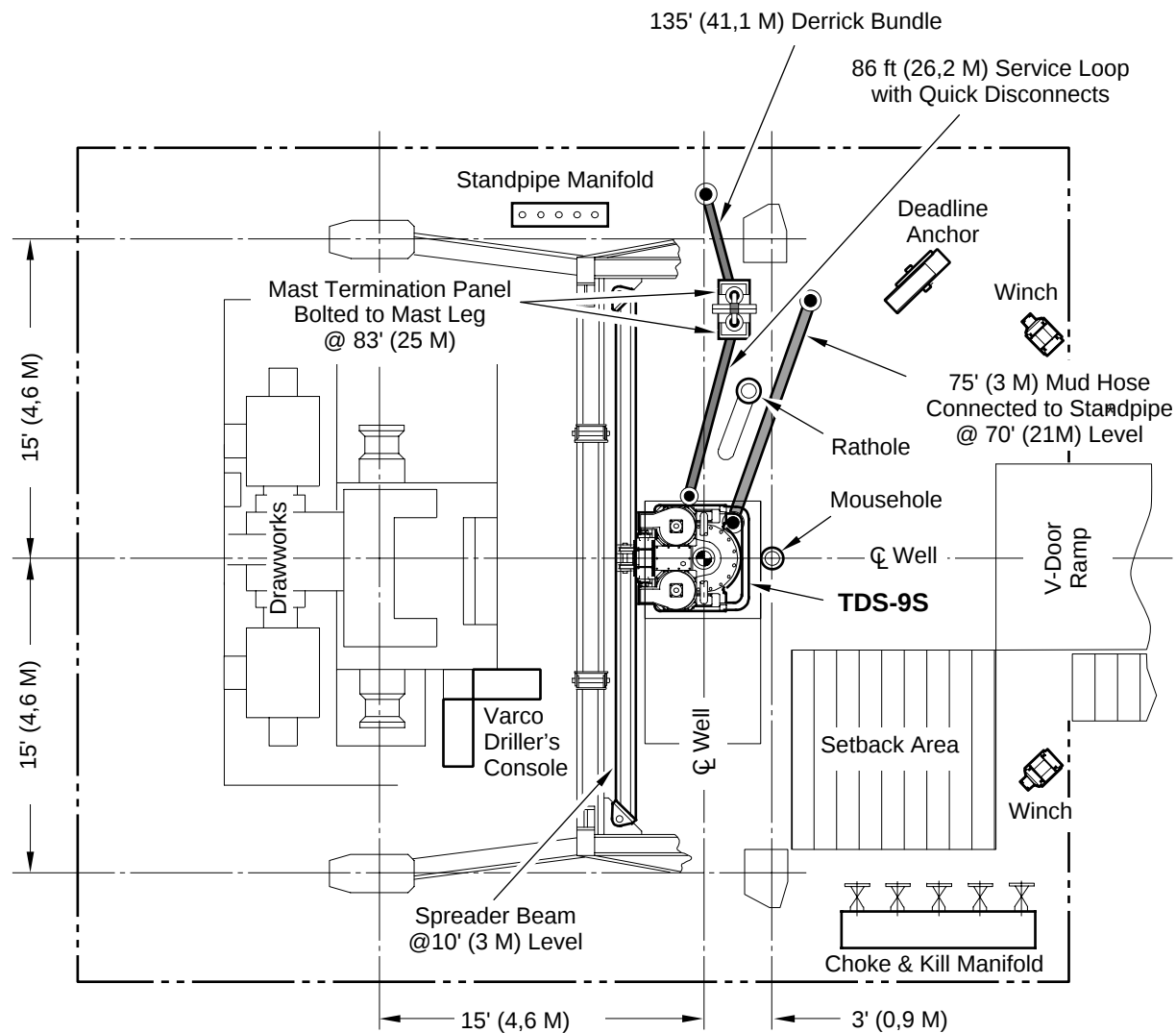
## Hydraulic system

|                    |                            |
|--------------------|----------------------------|
| Power              | 10 hp, 1,800 rpm, AC motor |
| Reservoir capacity | 25 gal                     |

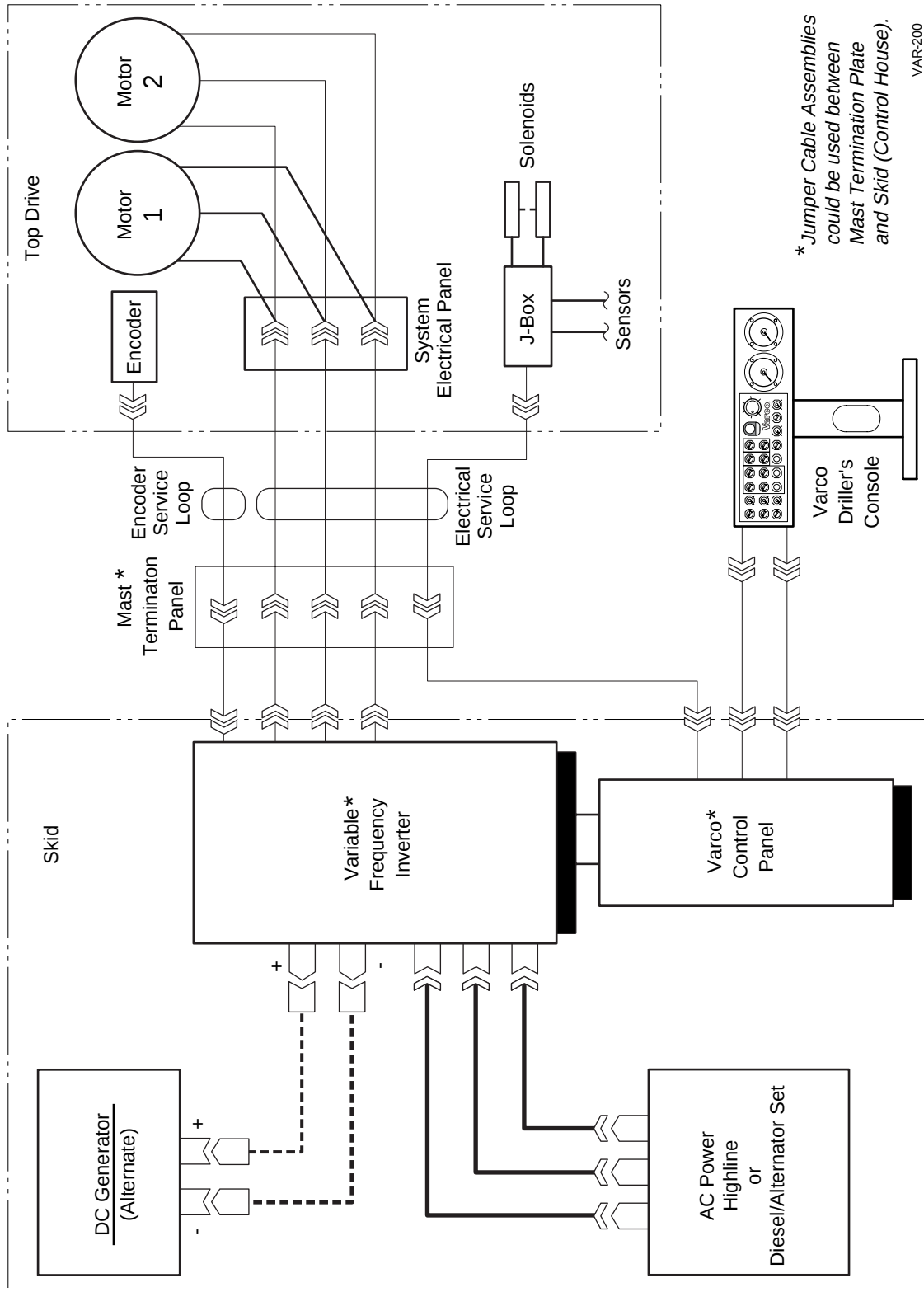
## System specifications

|                                    |              |
|------------------------------------|--------------|
| Horsepower                         | 700          |
| Tool torque (continuous)           | 32,500 ft lb |
| Tool torque (intermittent @ stall) | 50,000 ft lb |

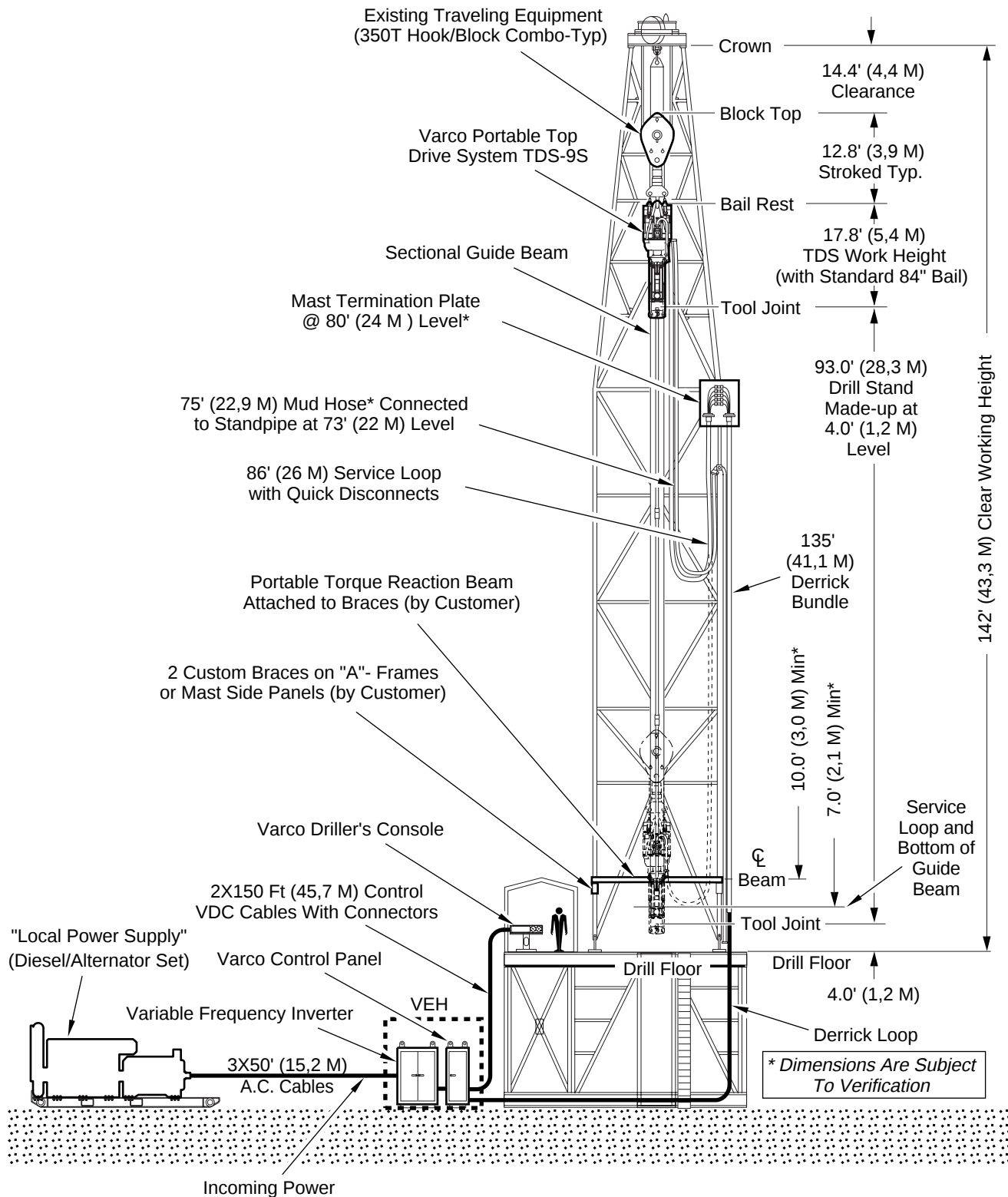
# Diagrams



**TDS-9S. Typical drill floor layout**



**TDS-9S. Electrical interface (power source possibilities)**



**TDS-9S. Typical mast interface**

---

**TDS-9S**

**Top Drive  
Drilling  
System**

**Installation**

---

March 9, 1998

# Contents

## Chapter 1 Preparation

|                                                       |      |
|-------------------------------------------------------|------|
| Preparation and pre-installation considerations ..... | 2-5  |
| Pre-installation checklist .....                      | 2-10 |

## Chapter 2 Installation

|                                                            |      |
|------------------------------------------------------------|------|
| Installing the guide beam and lower attachment .....       | 2-11 |
| Installing the rotary hose .....                           | 2-20 |
| Installing the derrick electrical termination .....        | 2-20 |
| Installing the driller's console and instrumentation ..... | 2-22 |
| Varco driller's console (VDC) .....                        | 2-22 |
| Wiring .....                                               | 2-22 |
| Installing the electrical service loop .....               | 2-23 |
| Installing the counterbalance system .....                 | 2-26 |
| Installing the tool joint lock .....                       | 2-28 |
| Removing the tool joint lock.....                          | 2-32 |
| Reinstalling the tool joint lock .....                     | 2-32 |

## Chapter 3 Commissioning

|                                                     |      |
|-----------------------------------------------------|------|
| Checkout procedure.....                             | 2-33 |
| Hydraulic system .....                              | 2-33 |
| Checking the fluid level and filter condition ..... | 2-33 |
| Pre-charging the accumulators .....                 | 2-36 |
| Setting up the pumps .....                          | 2-40 |
| Setting up the counterbalance circuit .....         | 2-44 |
| Setting up the brake circuit .....                  | 2-46 |
| Setting up the rotating link adapter circuit .....  | 2-46 |
| Setting up the IBOP actuator circuit .....          | 2-46 |
| Setting up the shot pin cylinder circuit .....      | 2-46 |
| Setting up the link tilt circuit .....              | 2-48 |
| Electrical system .....                             | 2-49 |
| Long term TDS-9S storage procedures .....           | 2-50 |
| Returning the TDS-9S to service after storage.....  | 2-52 |
| TDS-9S Installation checklist (FIP00003) .....      | 2-52 |

March 9, 1998



# Chapter 1

## Preparation

### **Preparation and pre-installation considerations**

---

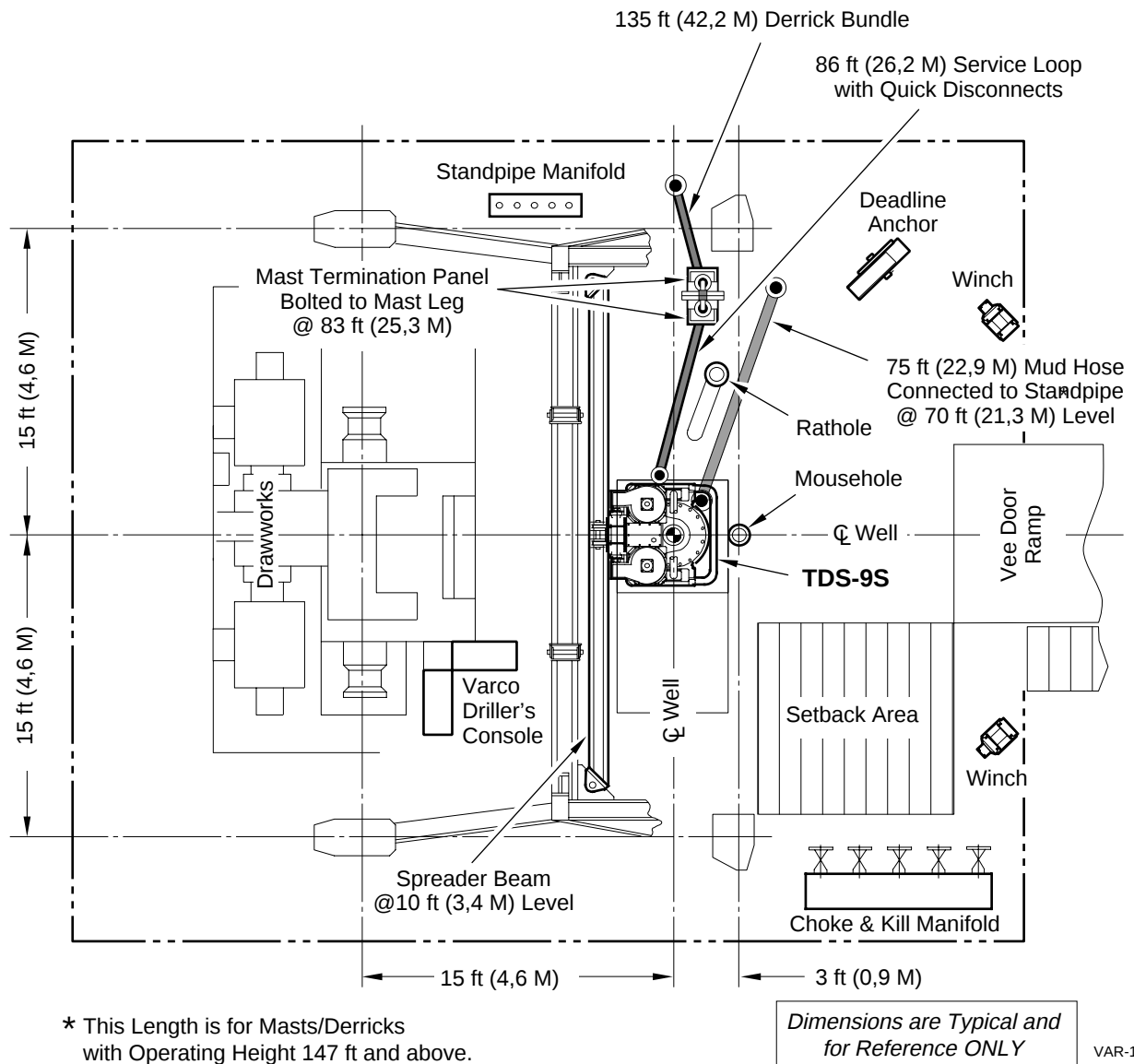
The TDS-9S interfaces with the rig's hoisting system and electrical power system. Derrick and electrical system modifications are required when installing the TDS-9S on existing rigs.

For derricks that handle triples, the required top drive travel is about 100 ft. compared to about 75 ft. when using a Kelly. It is generally necessary to replace the regular rotary hose (which is normally 60 ft. long) with a 75 ft. hose, and extend the standpipe height to 70 ft.

Although many rig floor layouts are possible, installing the guide beam on the drawworks side of the derrick, or mast, and opposite the V-door is an ideal arrangement for handling tubulars from the V-door (Figure 2-1).

The location of the electrical loop and mud hose is an important installation consideration for pipe setback purposes, to ensure proper clearance and to help prevent wear to the service loop and mud hose. Other important installation considerations include the location of:

- ☐ The casing stabbing board
- ☐ Floor and derrick accessories
- ☐ Drawworks fastline
- ☐ Guide beam hang-off bracket
- ☐ Torque reaction beam
- ☐ Mud stand pipe extension
- ☐ Varco drillers console location
- ☐ Variable frequency inverter/Varco control panel location

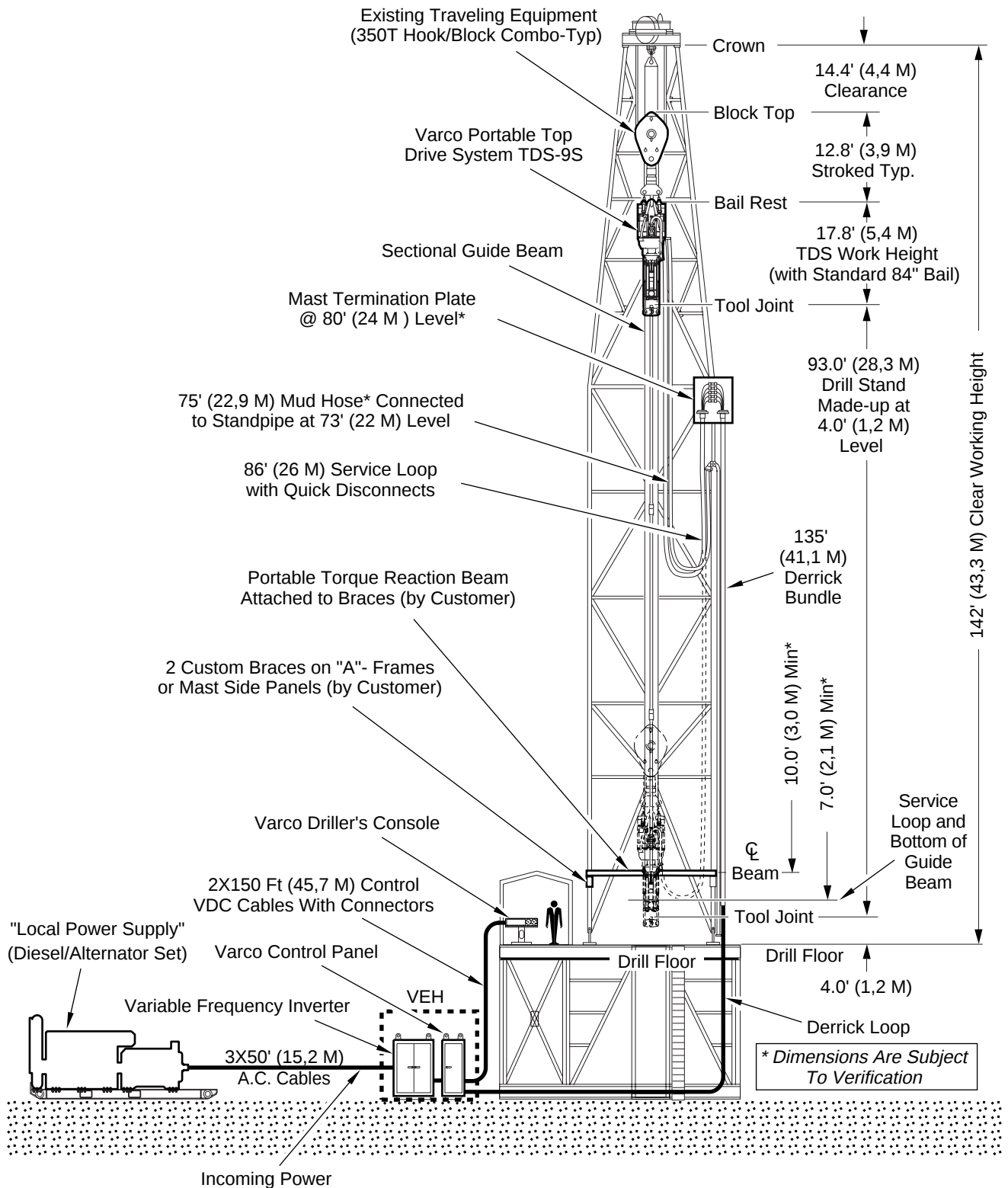


**Figure 2-1. Typical TDS-9S installation**

Derrick height is a critical interface requirement. Handling a 93 ft. stand typically requires 97 ft., resulting in an overall height from the floor to the top of the traveling block of at least 126 ft.

| <b>Derrick Clear<br/>Working Height</b> | <b>Derrick<br/>Crown Clearance</b> |
|-----------------------------------------|------------------------------------|
| 152 ft.                                 | 25 ft.                             |
| 147 ft.                                 | 20 ft.                             |
| 142 ft.                                 | 15 ft.                             |
| 136 ft.                                 | 9 ft.                              |

Each rig has different crown clearance for efficient tripping. Figure 2-2 illustrates typical derrick height interface requirements. Installing the TDS-9S with existing traveling equipment may require an adapter—further reducing crown clearance.



**Figure 2-2. Typical TDS-9S mast interface requirements**

# Pre-installation checklist

---

The following assumes that all pre-installation planning and rig-up is complete prior to installation of the guide beam assembly and TDS-9S. This includes:

- ☐ Make sure the derrick/mast is vertical, with the block over the center of the rotary table.
- ☐ Derrick/mast modifications are completed (if required) and the guide beam support bracket and torque reaction beam are installed and inspected to conform to Varco specifications as detailed in FIP00003.
- ☐ The service loop bracket is installed in the derrick/mast.
- ☐ The control panel and frequency drive are installed.
- ☐ Rigging of tong lines, etc. is inspected to ensure that they will not foul with the TDS-9S.
- ☐ The hook or adaptor becket is installed. The hook should open toward the drawworks.

## Installation

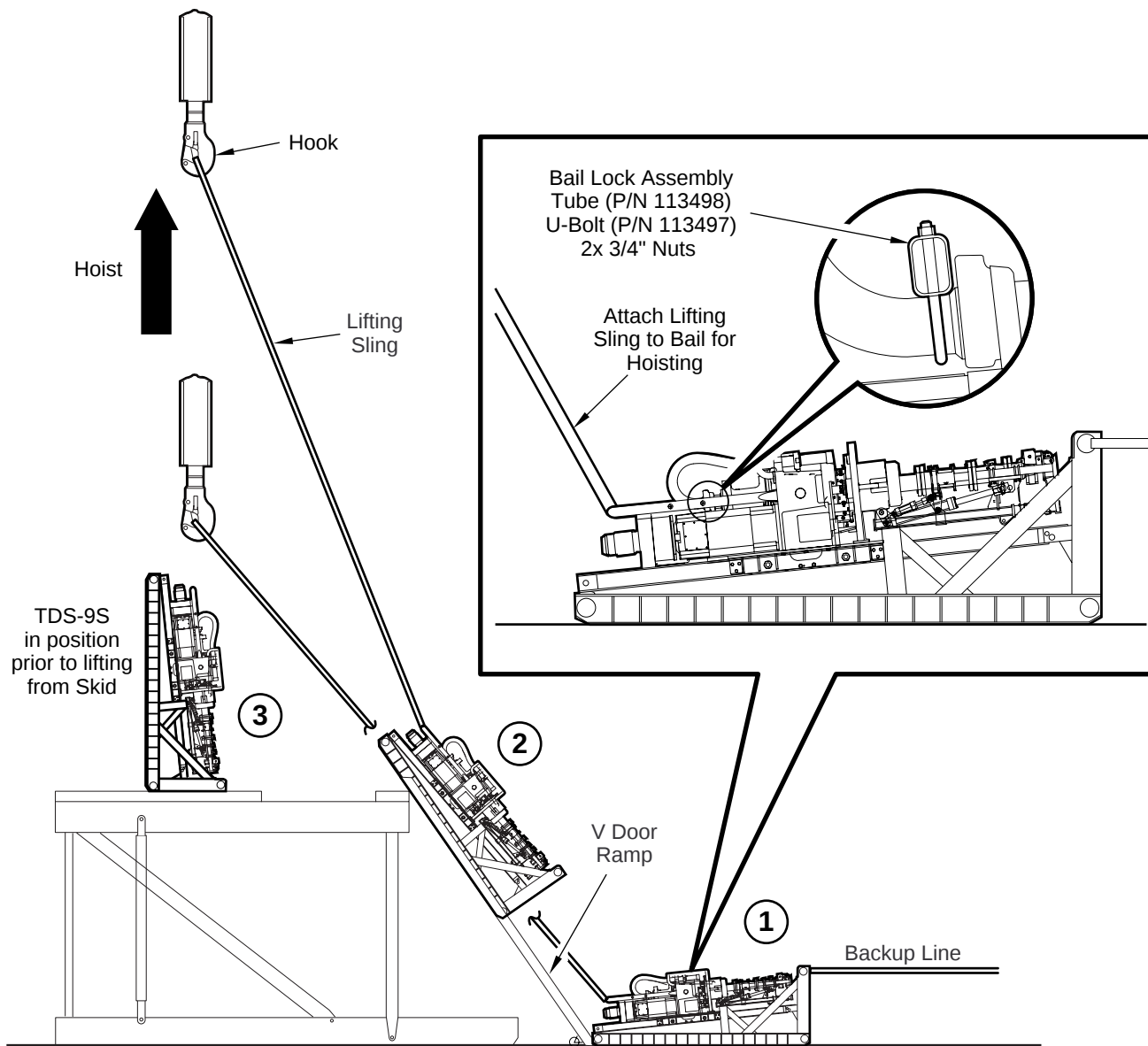
### **Installing the guide beam and lower attachment**

---

The TDS-9S is supplied in a shipping and handling skid which is attached to the upper guide beam section. The TDS-9S is supported by the guide beam in this skid. Use the following procedure for installation.

1. Install the connecting link to the crown.

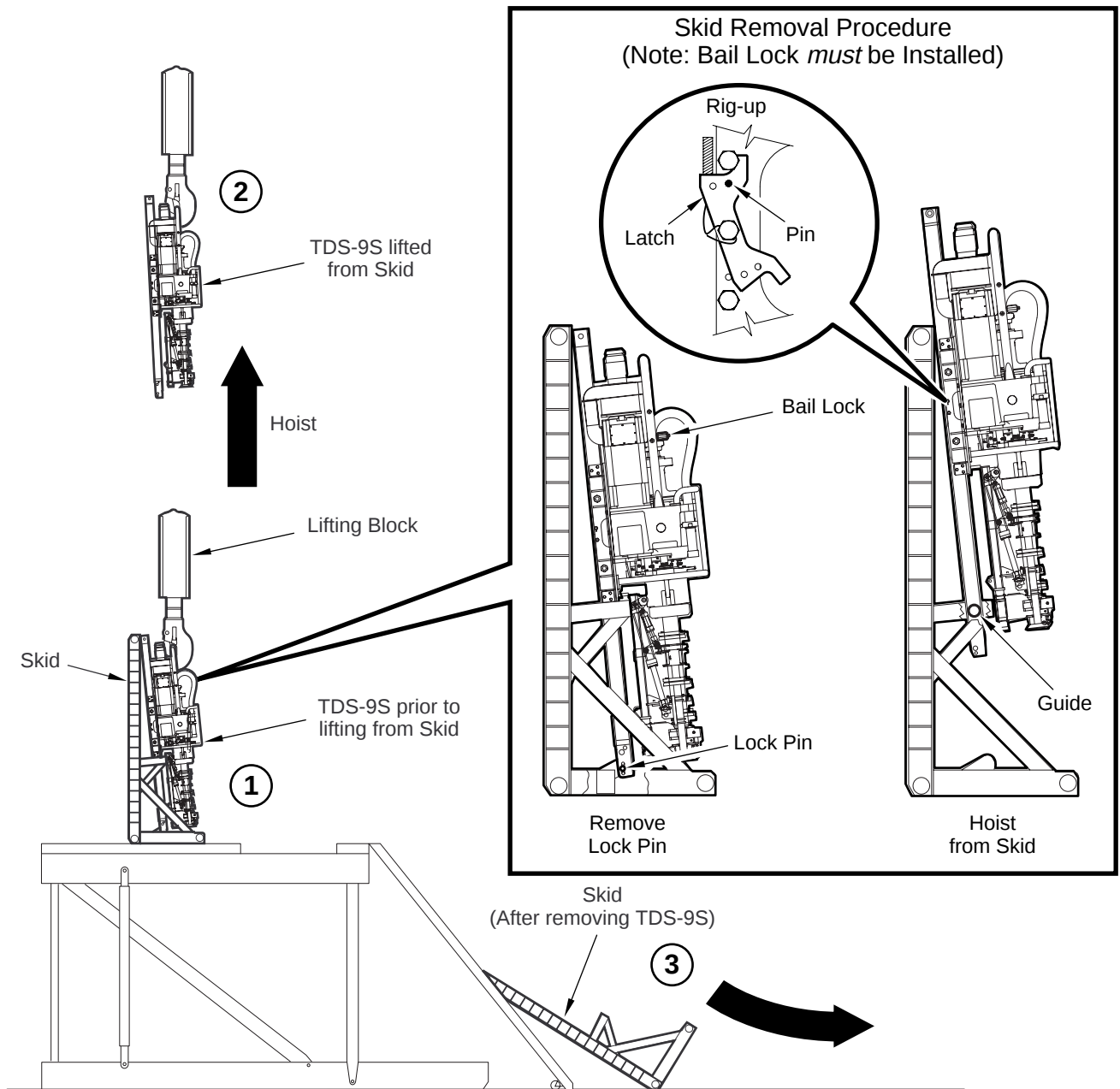
2. Attach a sling to the TDS-9S and move the TDS-9S up the V-door ramp to the drill floor (Figure 2-3). Be sure that the bail lock assembly is installed.
3. Attach a backup line to the bottom of the shipping skid (Figure 2-3).



**Figure 2-3. Moving the TDS-9S to the drill floor**



4. Attach the hook to the bail. Remove the lock pin. Make sure the carriage stop is engaged (Figure 2-7). Lift the TDS-9S from the skid using the drawwork (Figure 2-4).
5. Remove the skid from the drill floor.
6. Lower the TDS-9S to the drill floor with the traveling block.

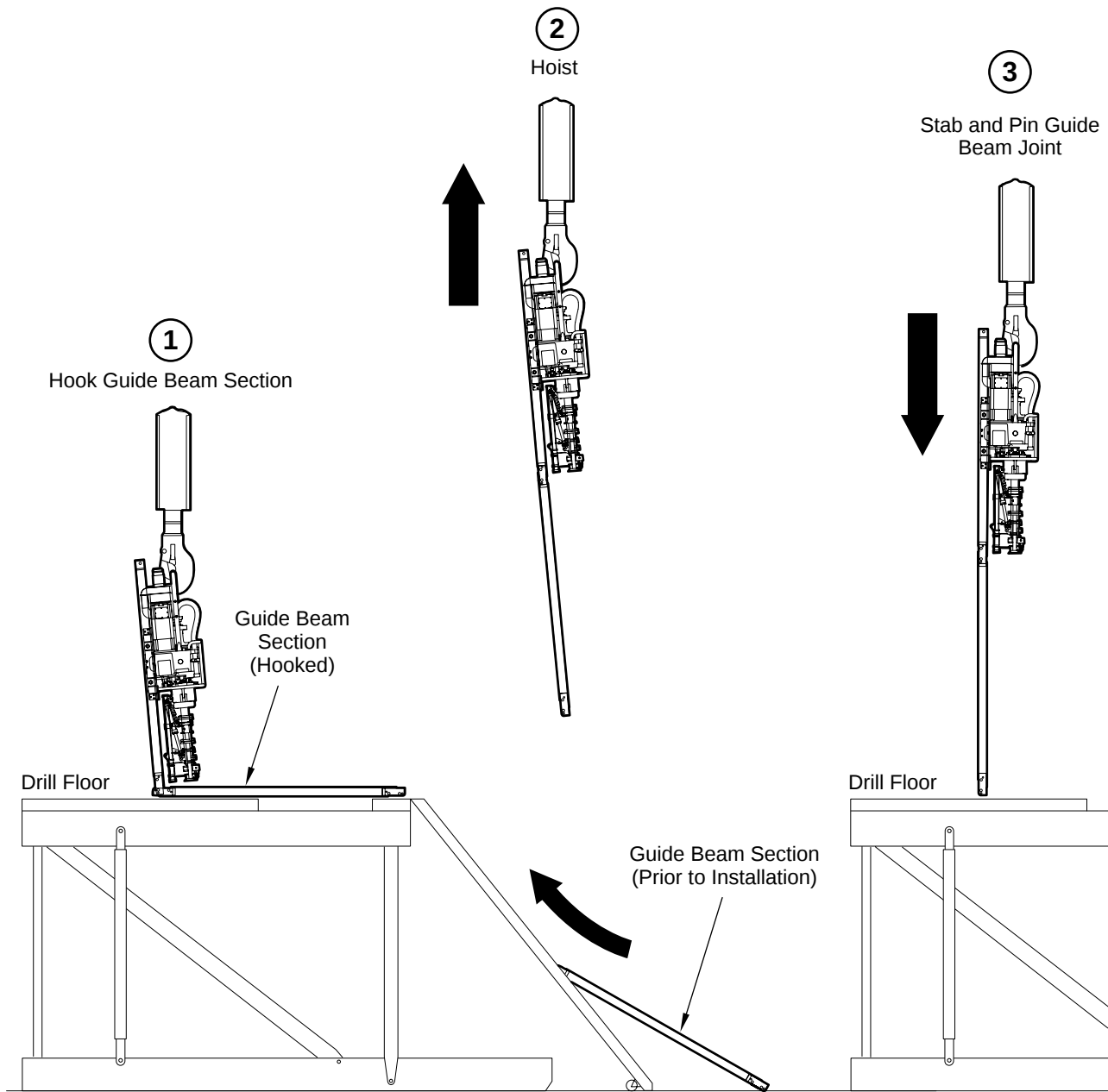


**Figure 2-4. Removing the TDS-9S from the skid**

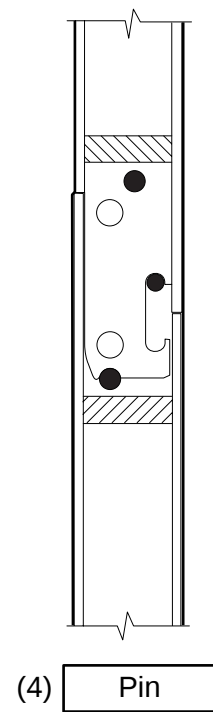
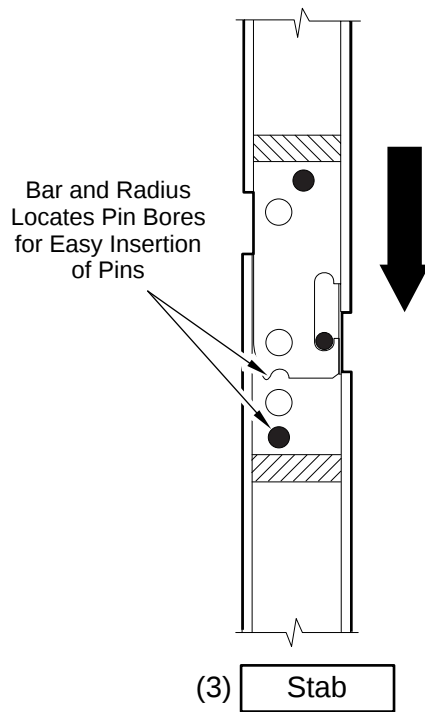
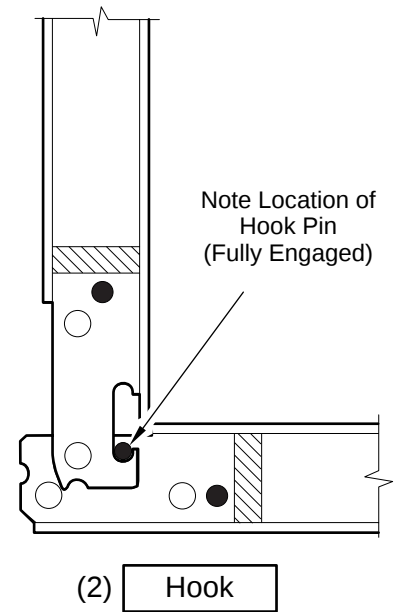
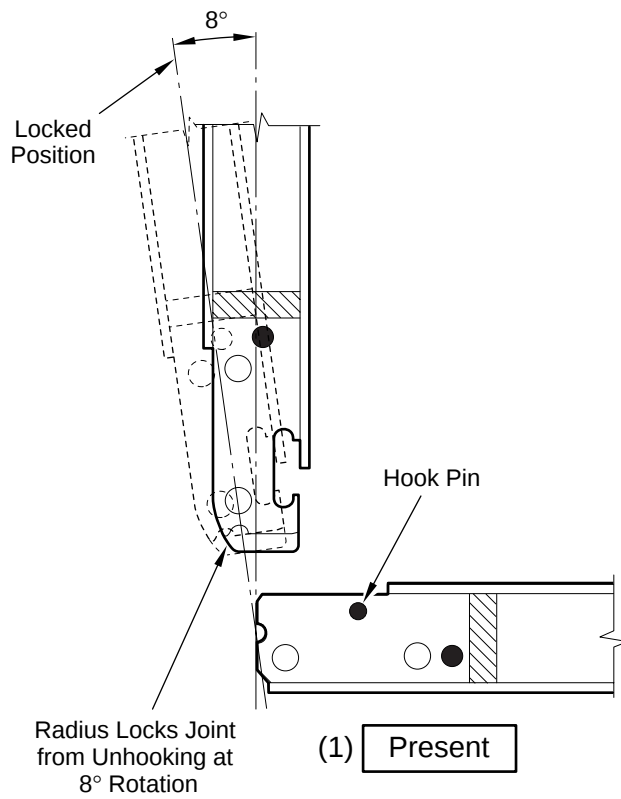
7. Bring the next guide beam to the drill floor. Dope or grease the bores on both joint halves. Hook, hoist, stab, and pin (Figures 5 and 6).



***Clear everyone from the area beneath, or near, the guide beam during rig up.***



***Figure 2-5. Installing the first guide beam section***



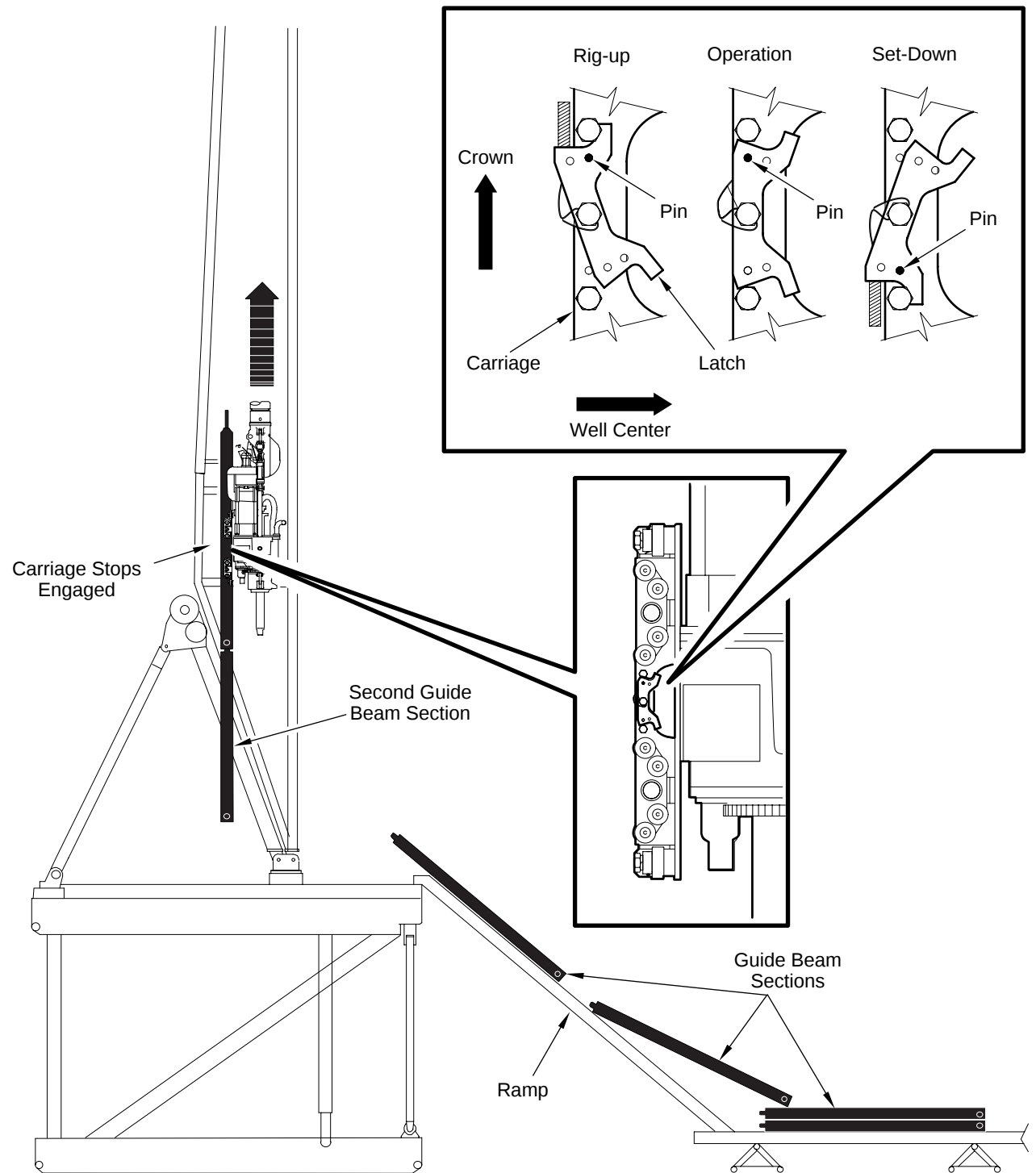
**Figure 2-6. Present, hook, stab and pin**

8. Repeat step 5 until all sections are attached.



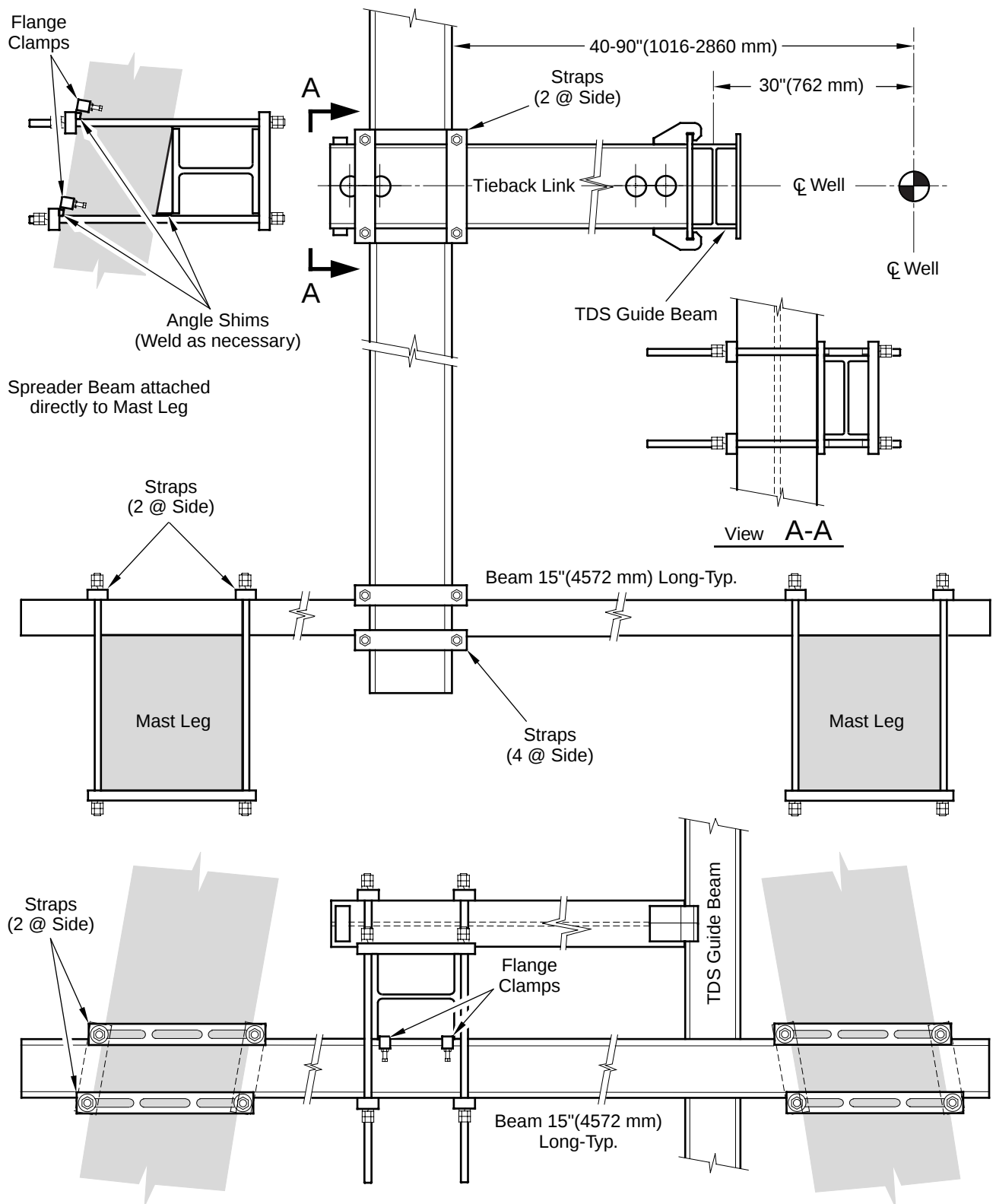
The attaching sequence may vary for custom guide beam sections, such as tops, bottoms, or intermediate sections.

9. Raise the TDS-9S and guide beam sections with the traveling block (with guide beam stops engaged) until the second section bottom is positioned at the drill floor, ready to be pinned to the next section (Figure 2-7).



**Figure 2-7. Installing the second guide beam section**

10. Bring the next guide beam section to the drill floor and pin the section to the bottom of the lower guide beam section.
11. Repeat the guide beam attachment procedures in steps 6 through 9 until the TDS-9S is at the top of the mast.
12. Attach the upper guide beam to the connecting link with the supplied shackle. Lower the traveling block slightly and pin the guide beam hook into the retracted position. Attach the lower attachment to the guide beam (Figure 2-8).



**Figure 2-8. Complete mast installation**

## Installing the rotary hose

---

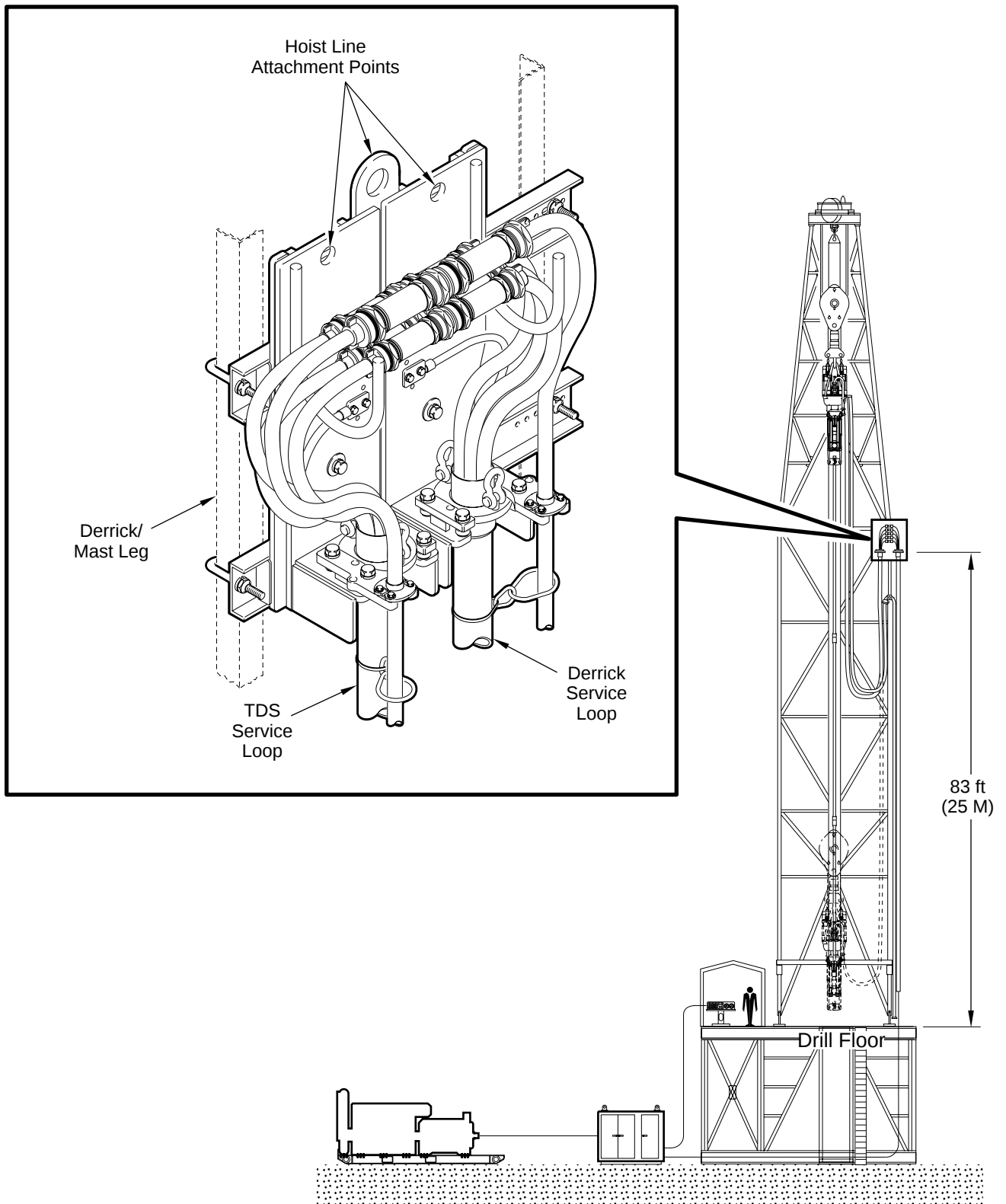
1. Remove the 4 in. female API line thread elbow coupling from the end of the S-pipe and install it onto the TDS-9S end of the rotary hose.
2. Install the hammer union end of the coupling to the S-pipe and tighten. Verify that the orientation of the rotary hose does not cause interference in the rig.

## Installing the derrick electrical termination

---

For cable requirements and routing, refer to Figure 2-9 and the TDS-9S wiring schematic.





**Figure 2-9. Typical TDS-9S electrical derrick termination**

# Installing the driller's console and instrumentation

---

## Varco Driller's Console (VDC)

The description and operation of the TDS-9S driller's console is contained in the *Operation* book.

Mount the driller's console within easy reach and in plain view of the driller while the drawworks brake and clutches are being operated. The gauges must be easily seen by the driller during drilling operations.

## Wiring



***Customers who choose to use control systems that are not manufactured by Varco should be aware that Varco systems are specifically designed with operational interlocks and safety devices to prevent possible injury to personnel and damage to the system. Other control systems must meet Varco requirements outlined in the QA 00098 document. Varco highly recommends the use of its system, as it is specifically made for use with the TDS-9S.***

# Installing the electrical service loop

---

Use the following procedures to install the electrical service loop as follows:

1. Install the service loop mounting bracket to the mast /derrick.
2. Bolt the service loop derrick mounting bracket to mast leg at the appropriate level (see the Derrick Interface drawing).  
Locate the mounting bracket on the side of the derrick adjacent to the brackets on the TDS-9S and as far away as practical from well center, to allow an adequate bend radius. The mounting bracket must be located far enough from the corner to ensure that the loops do not catch under the guide beam during operations, but far enough back to provide clearance for tong lines, the stabbing board, tugger lines, etc.
3. Do not unpack the service loop from the shipping crate or storage tub until it is ready to hang in the derrick.
4. Use the swivel at the tugger line attachment to allow the service loop to uncoil without twisting.

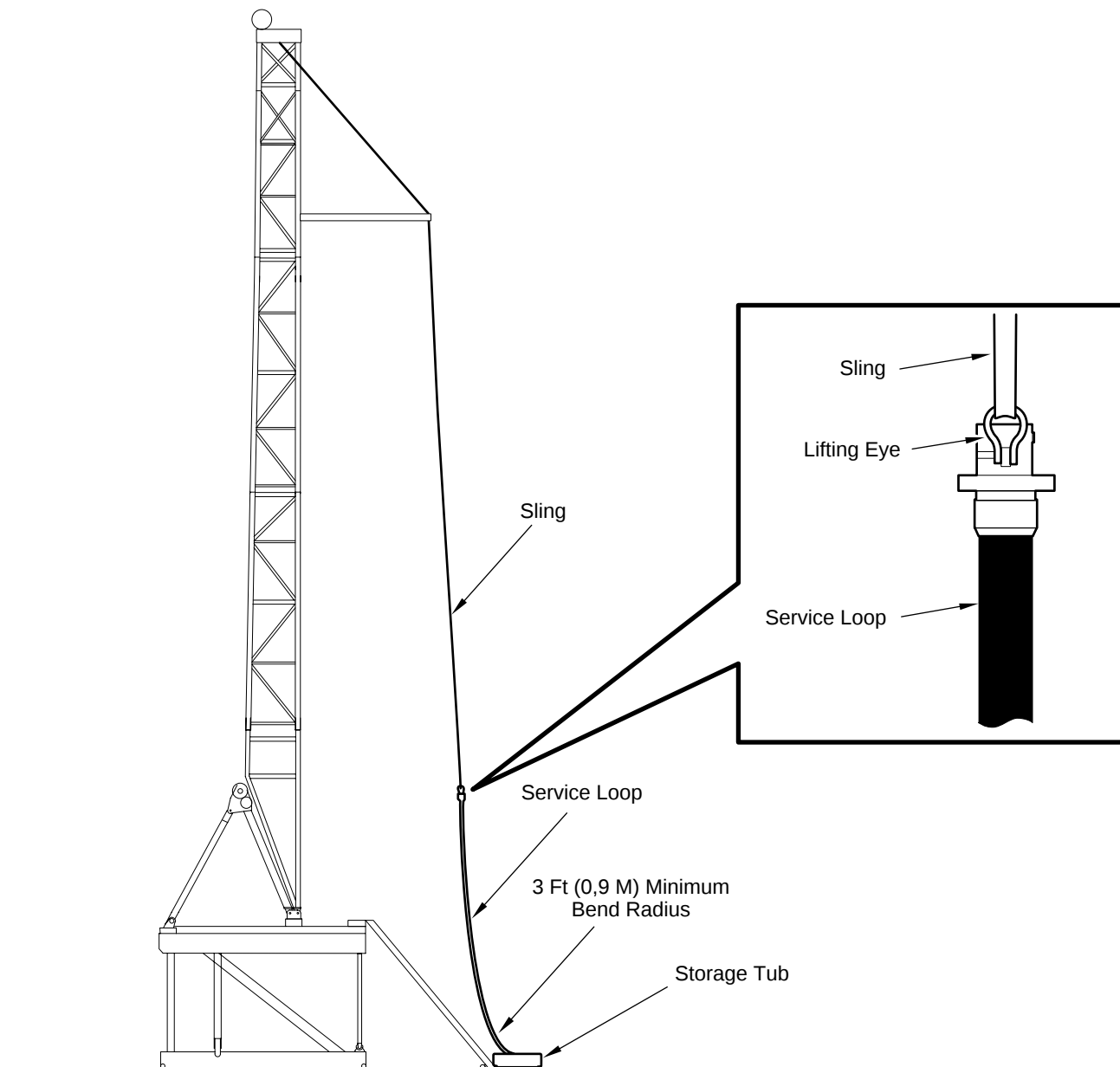


*Use care in rigging the lifting gear rigging so as not to damage electrical conductors. Lift service loop using lifting eyes only. Do not bend the service loop tighter than a three-foot bend radius or the service loop may be damaged.*

5. Lift the electrical service loop with a sling attached to the derrick end of the service loop. Allow enough room for the service loop to hang and untwist (Figure 2-10).



*Do not drag the loop across any sharp surfaces on the derrick.*



**Figure 2-10. TDS-9S Service loop installation**

6. Attach the derrick end to the derrick service loop bracket and hold it in place with flange clamps.
7. Pick up the TDS end of the loop and attach it to the service loop bracket on the top drive.
8. Connect cable ends in accordance with the electrical schematic.

Follow the same procedure as above for the encoder loop.

# Installing the counterbalance system

---

Use the following procedure to install the counterbalance cylinders (Figure 2-11):

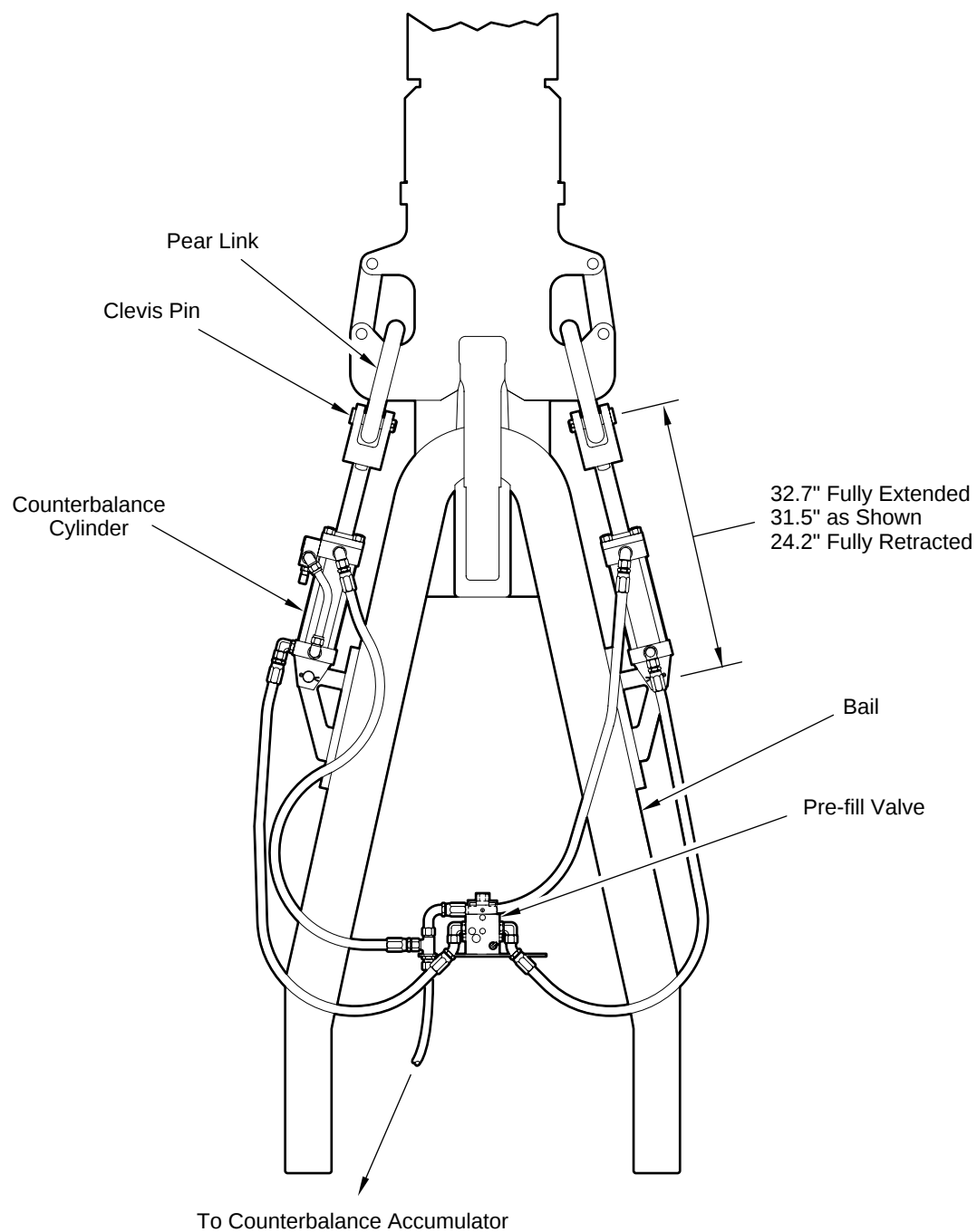
Refer to the *Setting up the counterbalance circuit* section of this book for initial system set up.

1. Install the pear links to the ears on the hook block.
2. Turn on the Top Drive power.
3. Rotate the counterbalance mode valve from the RUN position to the RIG-UP position.



*The cylinder strokes to the end of stroke when the mode valve is in the run position.*

4. When the cylinders reach the end of stroke, slide the cylinder clevis over the pear link and install the cylinder clevis pin.
5. After securing the counterbalance cylinder to the pear link, rotate the counterbalance mode valve back to the RUN position.
6. Adjust PCC clockwise to raise the pressure at test port CB until the bail just begins to lift off of the hook. Reduce the pressure slowly (25 psi) to allow pressure to stabilize.



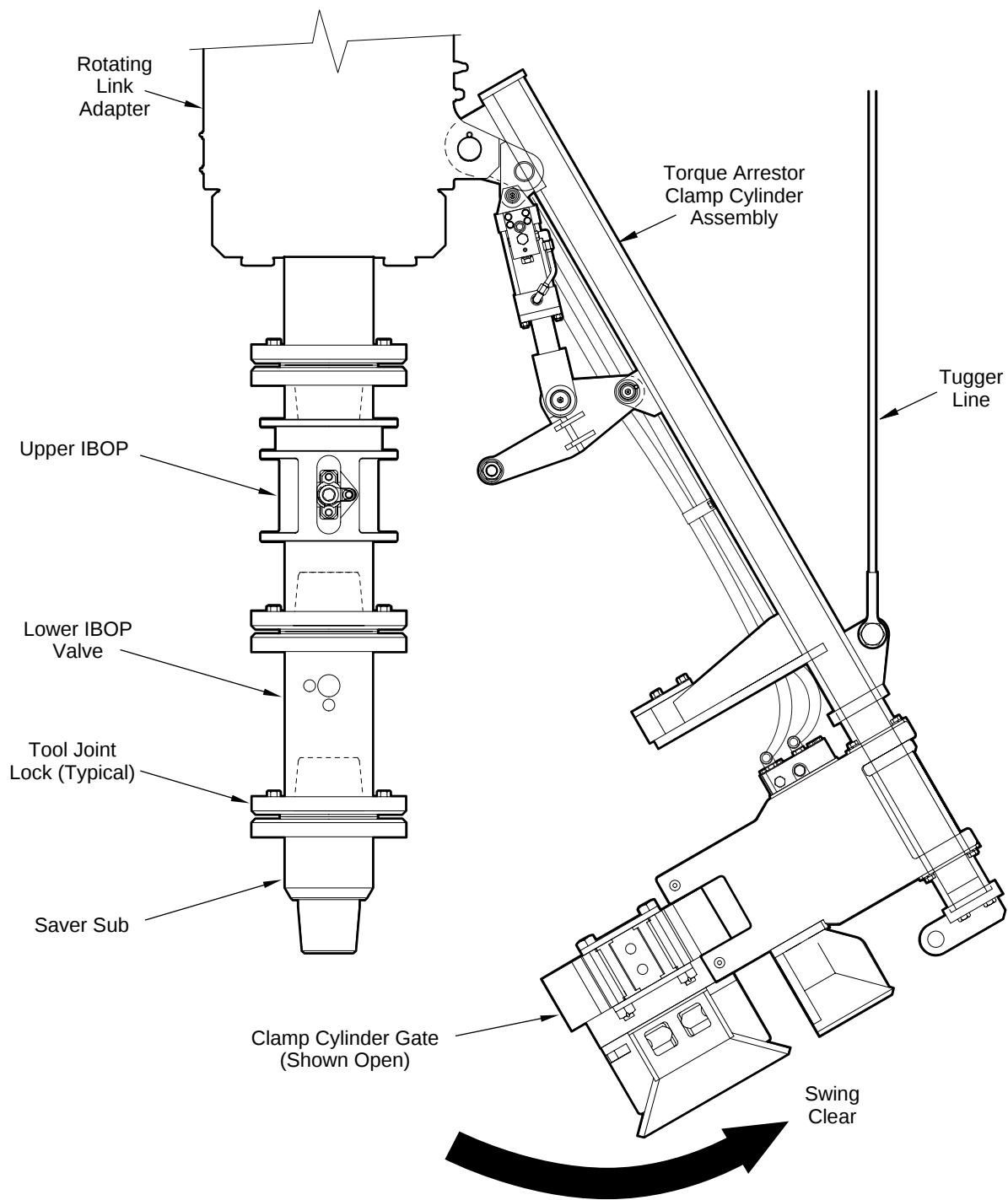
**Figure 2-11. Counterbalance installation**

# Installing the tool joint lock

---

During the installation of the TDS-9S, make up all three 6 5/8 in. API connections on the main shaft, IBOP valves and saver sub using a backup manual tong on the saver sub with the pipe handler swung away (Figure 2-12). The minimum torque for all three connections is 46,000 ft lb using the TDS-9S motors. Remove the tool joint lock between the saver sub and the lower IBOP, and the other two tool joint locks must be loose before applying torque.





**Figure 2-12. Preparing to install the tool joint lock**

Use the following procedure to install the tool joint lock:

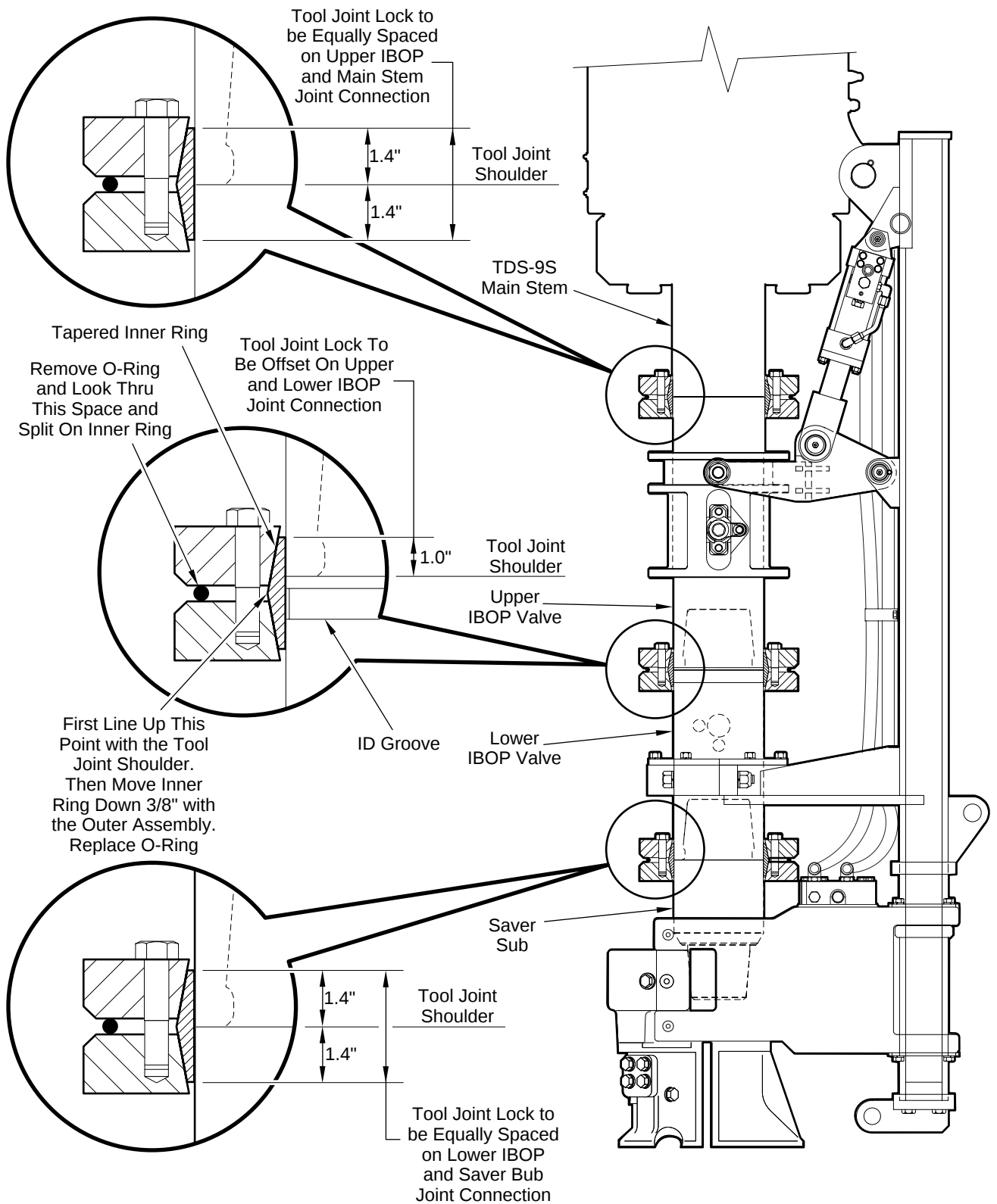


Never tighten locking screws before the tool joint lock is at the correct location, otherwise it will not slide freely.

1. Lubricate the supplied locking screw threads, screw head bearing area, and the tapers of the inner rings with molybdenum disulfide grease such as Molykote Gn paste.
2. Slide the tool joint lock over the main shaft, IBOP valves and saver sub.
3. Clean the IBOP valves, main shaft and saver sub surfaces thoroughly. Make sure these surfaces are smooth and free of grease and oil.
4. Locate the tool joint lock symmetrically at each joint (Figure 2-13).
5. Take any three or four locking screws equally spaced and tighten them to establish a parallel or perpendicular position of the tool joint lock collars relative to the main shaft, IBOP valves, and saver sub respectively. This properly seats the collars on the taper of the inner ring and aligns the collars.
6. Using a torque wrench, tighten all locking screws gradually in either a clockwise or a counterclockwise sequence (not in a diametrically opposite sequence). Continue tightening all of the screws until they reach *185 ft lb*.
7. Check and make sure that no screw turns any more. The gap between the tool joint collars should be as equal as possible all of the way around.
8. Safety wire all screws.



Check torque on bolts weekly or daily during hard drilling.



**Figure 2-13. Installing the tool joint lock**

## Removing the tool joint lock

---

The removal procedure is the reverse of the installation procedure. Note the following points:

1. Gradually release the locking screws all of the way around. Initially, release each screw about a quarter of a turn only, avoiding tilting and jamming the collars.



*Do not remove the screws completely at this time, otherwise collars may spring off.*

2. Remove any rust formed or dirt collected adjacent to the tool joint lock first. Once the screws are loose, remove the tool joint lock from the saver sub, IBOP valves and main shaft.

## Reinstalling the tool joint lock

---

Upon removal of the component, disassemble the unit. Clean and inspect all parts. Reinstall using the above installation procedure beginning with step 1.



*Do not re-use locking screws.*

# Chapter 3

## Commissioning

### Checkout procedure

---

#### Hydraulic system

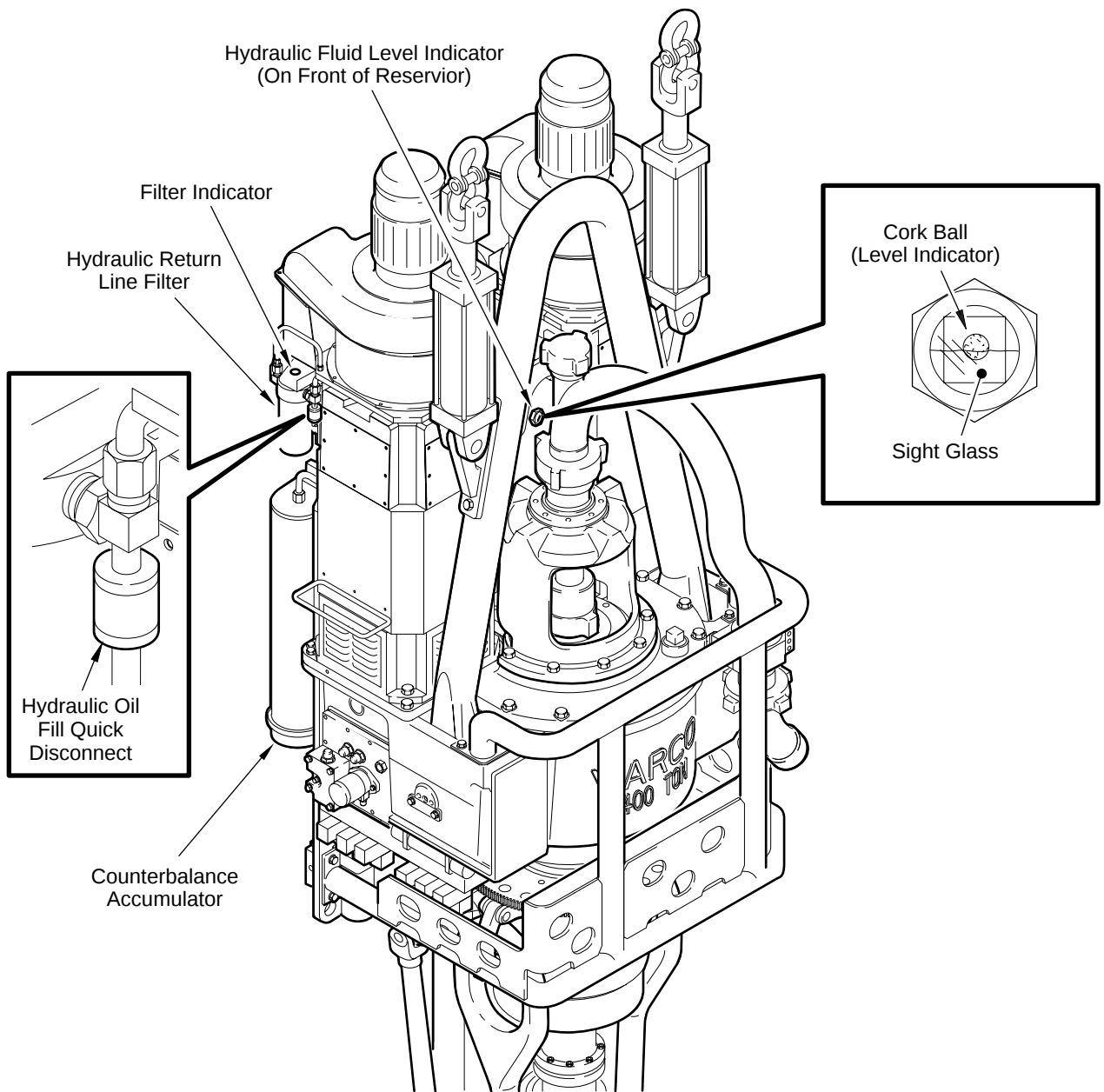
##### Checking the fluid level and filter condition



*In rigging up the TDS-9S for the first time, pre-charge all accumulators, adjust the hydraulic system, and bleed the air from the system. During this initial operating period, constantly monitor the hydraulic fluid level. Never allow the hydraulic fluid level to fall below the middle of the sight glass.*

Use the following procedure to check the fluid level and filter condition:

1. With the pipe handler clamp cylinder unclamped, counter-balance cylinders connected to the hook, the TDS-9S bail resting in the hook and the system power on, check to see that the hydraulic fluid level (indicator in sight glass) is at the middle of the upper sight glass, located on the reservoir, mounted between the AC drilling motors (Figure 2-14).
2. If the fluid level is low, add hydraulic fluid through the quick disconnect next to the filter, using the hand pump and filter hose provided by Varco.
3. Check the hydraulic return line filter indicator on the filter which is mounted on the left AC drilling motor (Figure 2-14). If the indicator is popped out, replace the filter by removing the oil filter bowl and installing a new filter element.



**Figure 2-14. Hydraulic fluid reservoir and filter**

## Pre-charging the accumulators

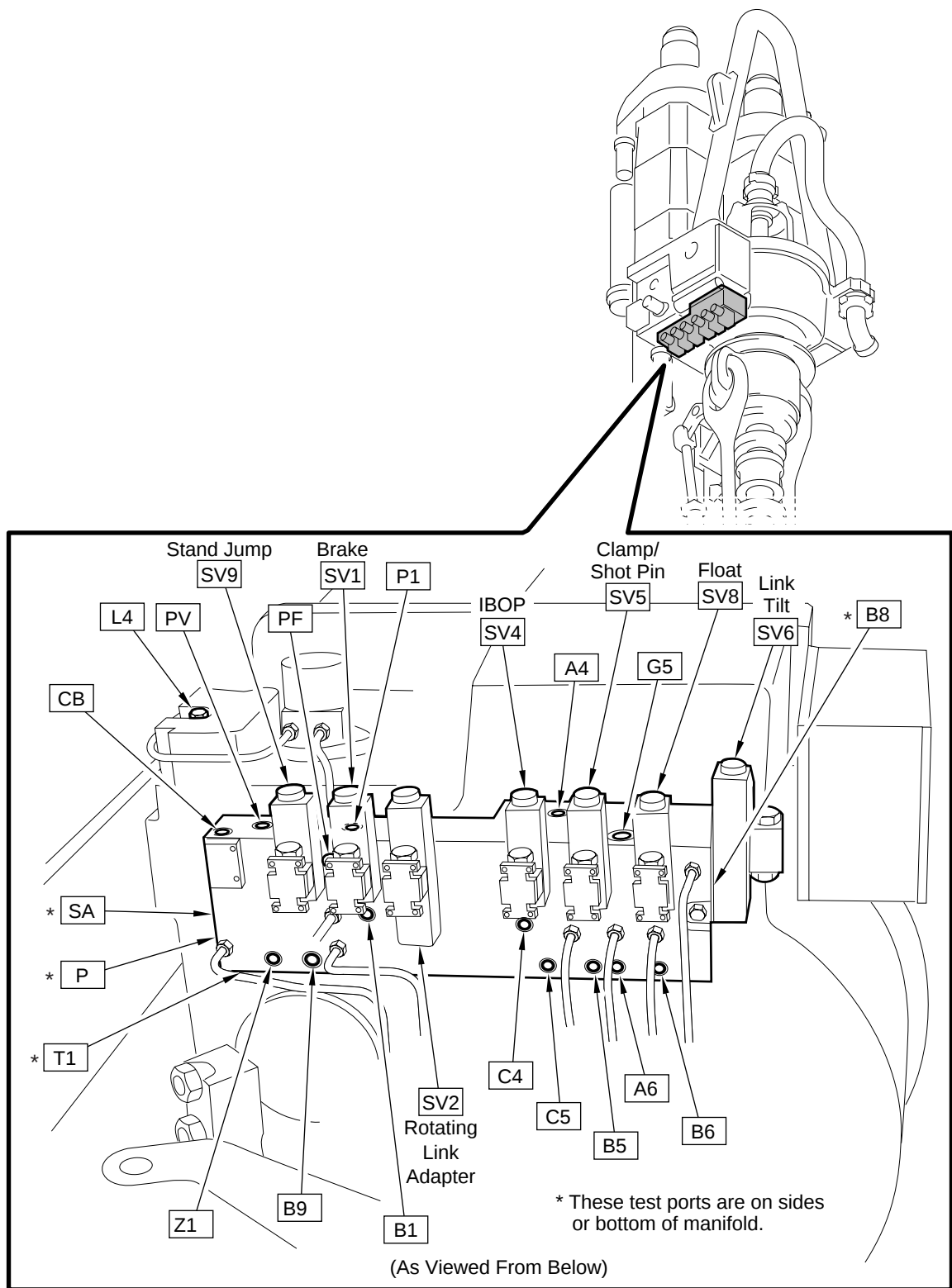
Use the following procedure to test the accumulators:

1. With the hydraulic system shut down, and the counterbalance mode valve in the SHUT DOWN position, test the hydraulic pressure at CB, SA and C4 on the hydraulic manifold, mounted to the transmission housing. Verify that all three points measure 0 psi (Figure 2-15).



There is a time delay in pressure decay on port C4.





**Figure 2-15. Hydraulic system manifold**

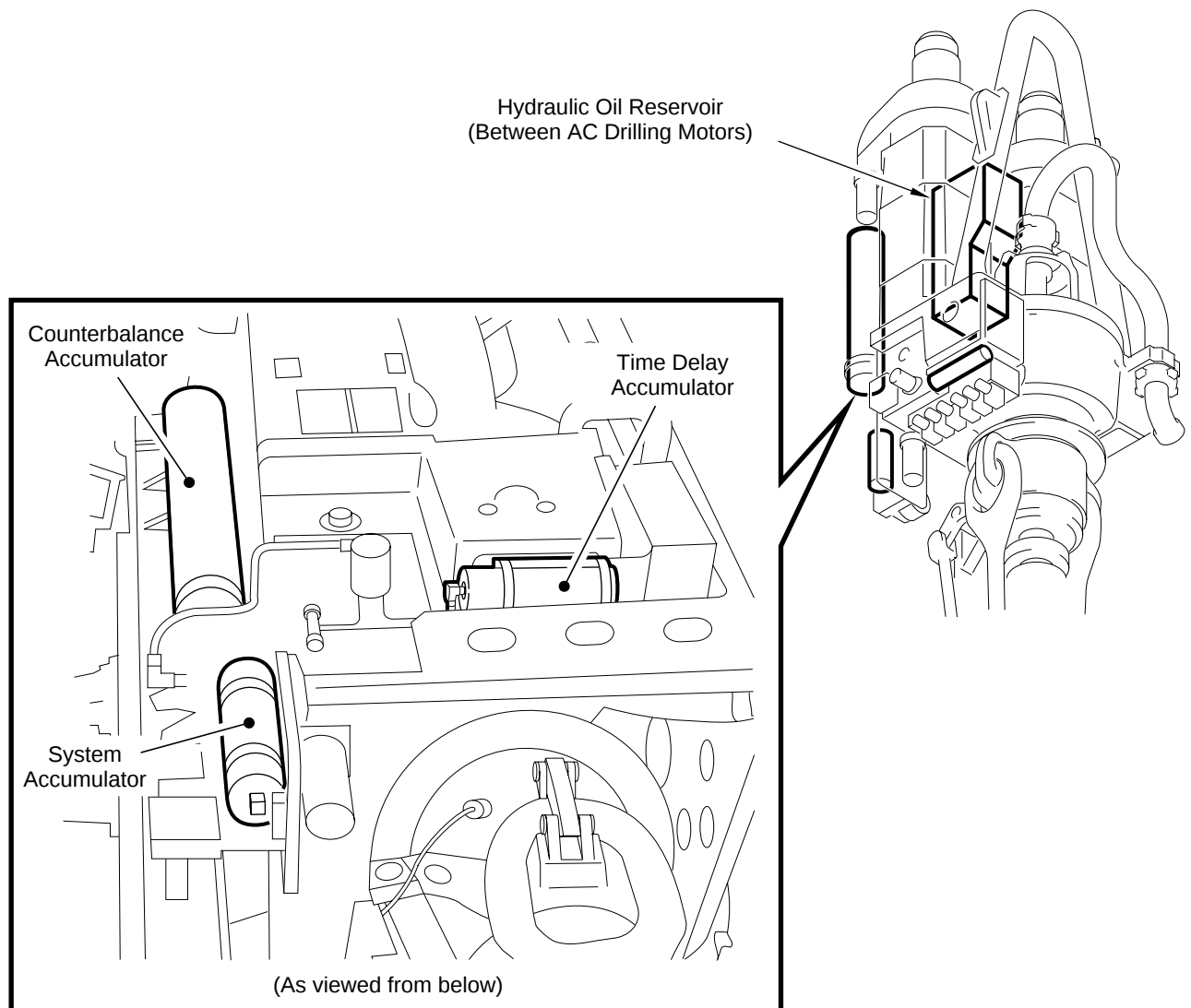
2. Test the precharge pressure on the following three nitrogen filled accumulators (Figure 2-16).
  - ☐ System Accumulator (125-cubic inch displacement) 800 psi precharge
  - ☐ Counterbalance Accumulator (728-cubic inch displacement) 900 psi precharge
  - ☐ Time-Delay Accumulator (30-cubic inch displacement) 800 psi precharge
3. Bleed the accumulator if the pressure is higher, or add nitrogen if the pressure is lower than specified in step 2.



*Use only nitrogen to charge accumulators. Use of other gases can cause an explosion.*



For setting up the pumps and hydraulic circuits, the TDS-9S must be mounted vertically with proper fluid fill in the gear box and hydraulic reservoir.



**Figure 2-16. Accumulators**

## Setting up the pumps

There are two pumps – a fixed displacement pump runs the transmission lubrication system and a variable displacement pump provides hydraulic flow to the hydraulic system.

1. Locate the tube connecting manifold port PF to the lubrication motor. Disconnect the tube at the manifold end, cap the tube and plug the PF port using steel fittings.
2. Set the relief valve RV1 for the variable displacement pump to a minimum setting, fully counterclockwise, which allows the hydraulic system to operate without building up pressure.
3. Set the relief valve RV2 to minimum pressure, fully counterclockwise.



Make sure the variable displacement pump case is filled with clean hydraulic oil.

4. Jog-start the electric motor to make sure the direction of rotation is correct (clockwise when looking into pump shaft/ electric motor fan). Correct as required.
5. Start the electric motor and allow both hydraulic pumps to circulate oil. Listen for unusual noises that would indicate cavitation; check for leaks.
6. Connect a gauge to test point PF. Increase the pressure by adjusting relief valve RV2 clockwise until the pressure increases to 400 psi at test point PF. Set the jam nut on RV2. A steel cap is installed over the adjustment screw to discourage unauthorized adjustment.

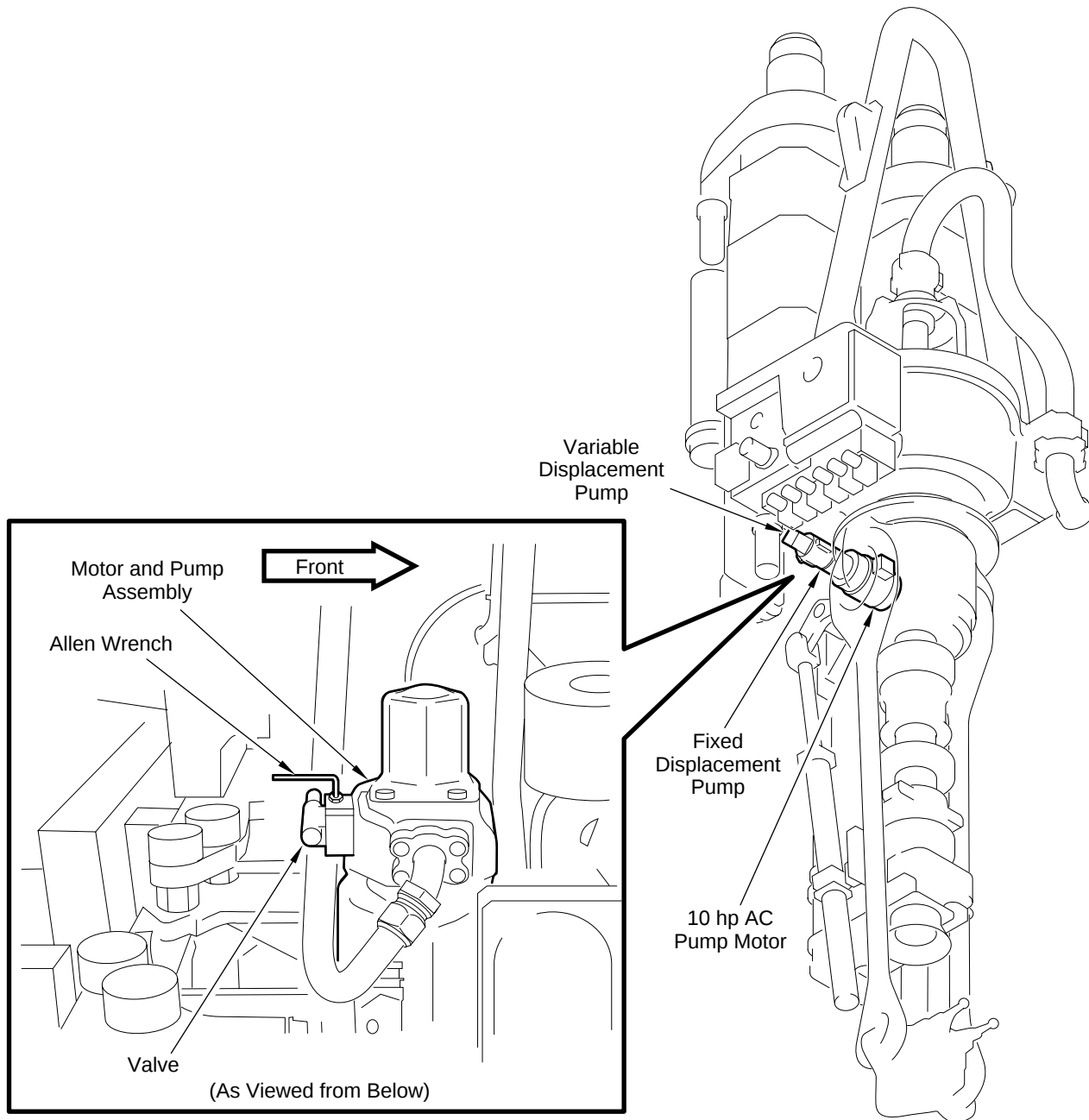


While adjusting valves, verify a linear relationship between turning the adjustment screw and observing the pressure change.

7. Turn off the electric motor. Reconnect the tube between manifold port PF and the lubrication motor.
8. Connect an ammeter to the electric motor. Note the full-load amps on the motor nameplate.
9. Restart the hydraulic system electric motor.
10. Set the counterbalance mode valve to the RUN position.

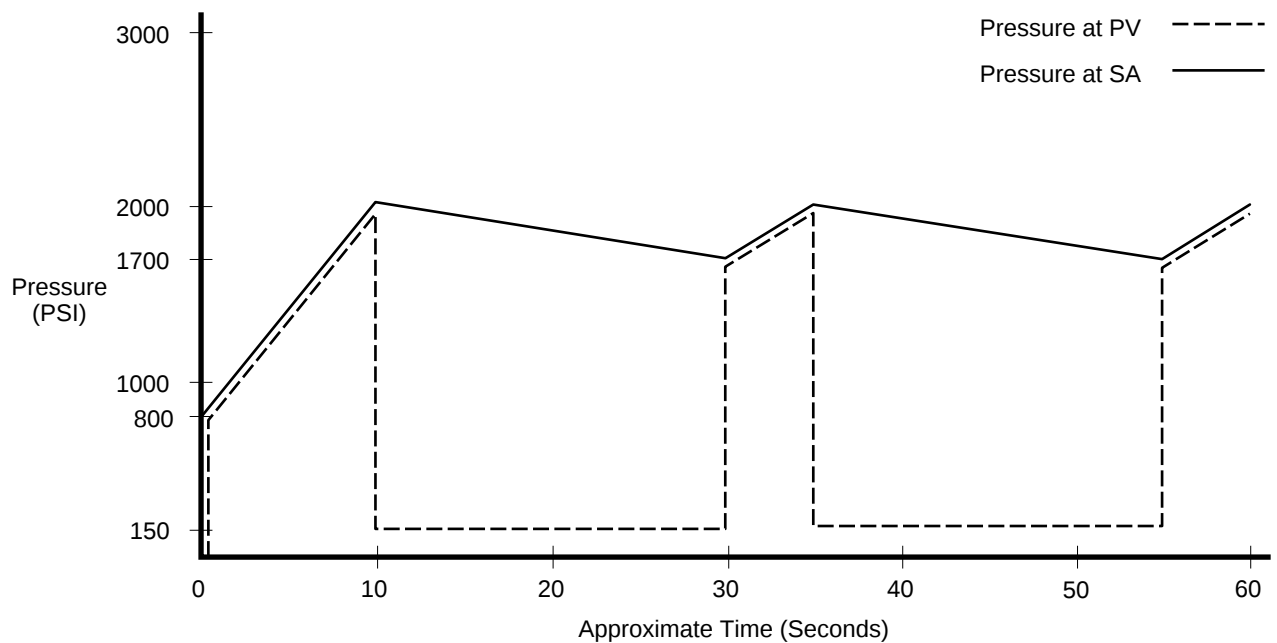
11. Adjust UV1, fully clockwise, to maximum pressure.
12. Connect a gauge to test point PV. Note the ammeter reading while RV1 is at minimum setting.
13. Raise the setting of relief valve RV1 from 0 psi to 1,500 psi at a steady rate. During the pressure rise, observe the ammeter. The motor current should rise to a maximum value at 800 psi, then drop off and begin to rise again. The point where the current drops is the pump pressure compensator setpoint.

14. Adjust relief valve RV1 to its minimum setting. If maximum motor current does not occur at 800 psi, adjust the pump pressure compensator as required (Figure 2-17).
15. Adjust relief valve RV1 again from 0 psi to 1,500 psi, and back to 0 psi to verify maximum motor current at 800 psi.



**Figure 2-17. Pump pressure compensator**

16. Connect a gauge to test point SA, and leave the gauge on PV.
17. Adjust relief valve RV1 to 2,200 psi and secure the jam nut.
18. Install steel cap over the adjustment screw to discourage unauthorized adjustment.
19. Adjust unloading valve UV1 counterclockwise until the pressure at PV drops off, then an additional two turns counterclockwise. The pressure cycles like a sawtooth wave (Figure 2-18).



**Figure 2-18. Pressure at SA and PV**

20. Observe the unloaded pressure at PV (about 0 psi) while SA reads about 2,000 psi. The pressure at SA decays until UV1 reloads. After reloading, the pressure rapidly rises to the unload pressure.
21. Observe several unload-reload cycles to determine the unload pressure.
22. Adjust the setting of UV1 as required to a 2,000 psi unload pressure.



*Perform the adjustment with reasonable speed. The process takes no longer than two minutes. Taking longer increases the temperature of the hydraulic fluid.*

23. Observe the cycle of loading and unloading of the relief valve. To verify the setting of UV1, note the difference in pump noise level between the loaded and unloaded condition.

## **Setting up the counterbalance circuit**

1. For the counterbalance circuit there are three adjustments:
  - ☐ Relief valve (on counterbalance cylinder)
  - ☐ PCC – operator set
  - ☐ SJR – operator set
2. To set the relief valve, make sure the pumps are operating.
3. Adjust pressure reducing valve PCC to the maximum setting, fully clockwise.
4. Connect a gauge to test port CB.
5. Adjust the cylinder-mounted relief valve to mid-scale to lower the pressure setting.
6. Increase the pressure clockwise using a 5/32 in. Allen wrench and 9/16 in. open-end wrench.
7. Observe the relationship of turning the relief valve adjustment clockwise to pressure increase.
8. When the relief valve reaches system pressure, turn the setting one full turn clockwise beyond the setting and set the jam nut.
9. Install a steel cover over the valve.
10. Adjust PCC to 1,200 psi.
11. Measure pressure at test port CB.
12. Prepare the hardware to attach the cylinder pear links to the hook.



13. Rotate the counterbalance mode valve from the RUN position to RIG-UP position. This causes the counterbalance cylinders to slowly extend.



*Cylinders stroke to the end of stroke with the mode valve in the RUN position.*

14. Once cylinders reach end of stroke, attach hardware to the pear links on the hook.
15. Rotate the counterbalance mode valve back to the RUN position.
16. Adjust PCC counterclockwise to raise the pressure at test port CB until the rail just begins to lift off of the hook.
17. Reduce the pressure slowly (25 psi) to allow the pressure to stabilize.
18. Rotate the counterbalance mode valve to the SHUTDOWN position to bleed down counterbalance cylinders and system accumulator before shipping or performing maintenance.
19. Adjust pressure reducing valve PCC counterclockwise until the bail rests on the hook. Note the pressure at CB.
20. Reduce PCC an additional 25 psi. The pressure at CB is about 1,600 psi.
21. Connect a gauge to test point B9. Activate the STAND JUMP mode on the drilling console. Adjust relief valve SJR until the bail lifts off the hook. The gauge at B9 should read about 190 psi.
22. Switch back to DRILL counterbalance mode and observe the pressure at test point CB.
23. Switch back to STAND JUMP mode and observe the pressure CB increase by 190 psi.

## Setting up the brake circuit

1. Test the pressure at port P1 to verify a set pressure of 1,400 psi. Adjust valve PC1, if the pressure is not 1,400 psi.
2. Test the pressure at B1. At B1 the pressure is 0 psi when the brake is off. When the brake is on, the pressure at B1 is 1,400 psi.

## Setting up the rotating link adapter circuit

1. Set the relief valves mounted on rotation motor.
2. Operate the clamp. The shot pin must go through the hole, which locks up the gear.
3. Turn the manual override on the SV2-rotation circuit to drive the head in the counterclockwise direction. Test the pressure at A and adjust the relief valve to 1,600 psi.
4. Turn the manual override on the SV2-rotation circuit to drive the rotating head in the clockwise direction and test the pressure at B. Adjust the relief valve to 1,600 psi.

## Setting up the IBOP actuator circuit

1. There is a pressure reducing valve PC4 for the IBOP actuator. With pressure gauges connected to A4, B4, and C4, adjust PC4 to achieve 500 psi at A4. Operate the IBOP CLOSED switch, and observe A4 at 0 psi, while B4 and C4 read 2,000 psi. Operate the IBOP OPEN switch and observe 2,000 psi at A4, and 0 psi at B4. Port C4 starts at 2,000 psi when the IBOP OPEN switch is commanded, and delays to 0 psi after about 30 seconds. When C4 delays to 0 psi, A4 reads 500 psi.

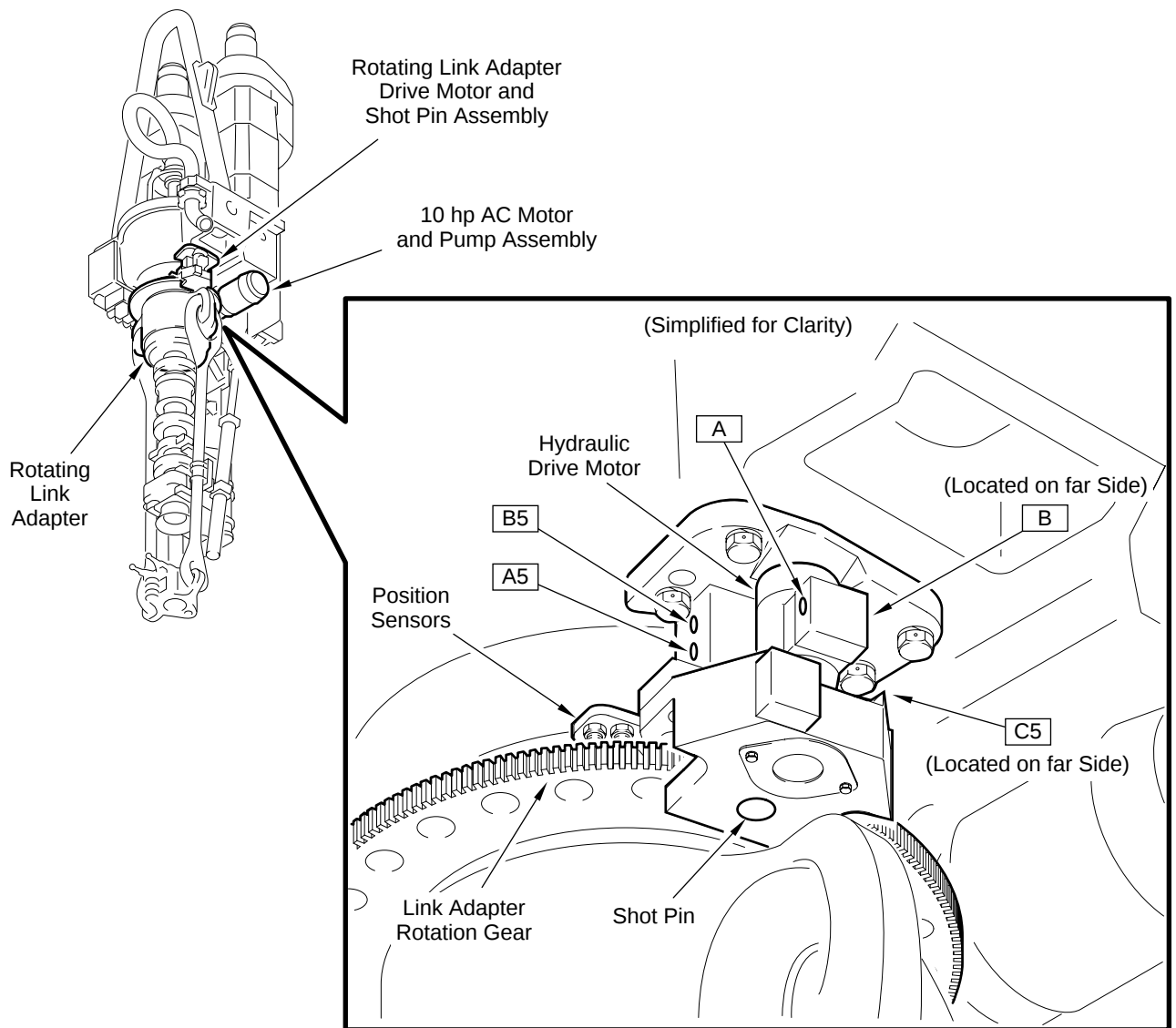
## Setting up the shot pin cylinder circuit

1. Set the adjustable relief valve near the body of the cylinder. The shot pin often misses the hole in the rotating gear. The force the shot pin exerts is limited until the pin engages a hole (Figure 2-19).



The electrical system jogs the rotating head until the pin engages a hole.

2. To limit the amount of force, you set the valve by operating solenoid valve SV5 manually, forcing the pin to stop on the face of the gear.



**Figure 2-19. Shot pin relief valves**

3. When the pin stalls out, measure the pressure at B5. Set the relief valve pressure to 200 psi.
4. Tighten the jam nut on the relief valve.
5. At rest, the SV5 valve is de-energized.
6. Test the pressure at C5. Adjust reducing valve AR5 to 500 psi.

## Setting up the link tilt circuit

1. There is nothing to adjust on the manifold for the link tilt circuit.
2. Adjust the four load holding valves in pairs – the upper pair and lower pair. Adjust all four counterbalance valves fully clockwise, then one turn counterclockwise.



If the valves are not adjusted correctly, link tilt operation is not synchronized.

3. The correct pressure setting is 1,500 psi. The procedure is the same for all four valves. Adjust the valves one at a time.
4. There is a test point on each loading manifold.
5. From the driller's console, move the link tilt to go to the mousehole position.
6. The cylinder goes to full extension and the pressure at the test port TP is 2,000 psi.
7. Command the link tilt to the OFF position and observe the pressure delay at TP. This delayed pressure is the setpoint of the counterbalance valve.
8. Raise the valve setpoint by turning the adjusting screw 1/4 turn counterclockwise.
9. Repeat steps 6 and 7 until the decayed pressure is 1,500 psi.



This is an iterative process. Continue to set the driller's console control to the mousehole position and OFF, taking present and decayed pressure readings.



*Turning the counterbalance valve counterclockwise increases the pressure.*

10. Repeat the procedure above for the other cylinder at the mousehole position.
11. Command the link tilt to the DRILL position and repeat the procedure above to set both counterbalance valves on the DRILL side.

## Electrical system



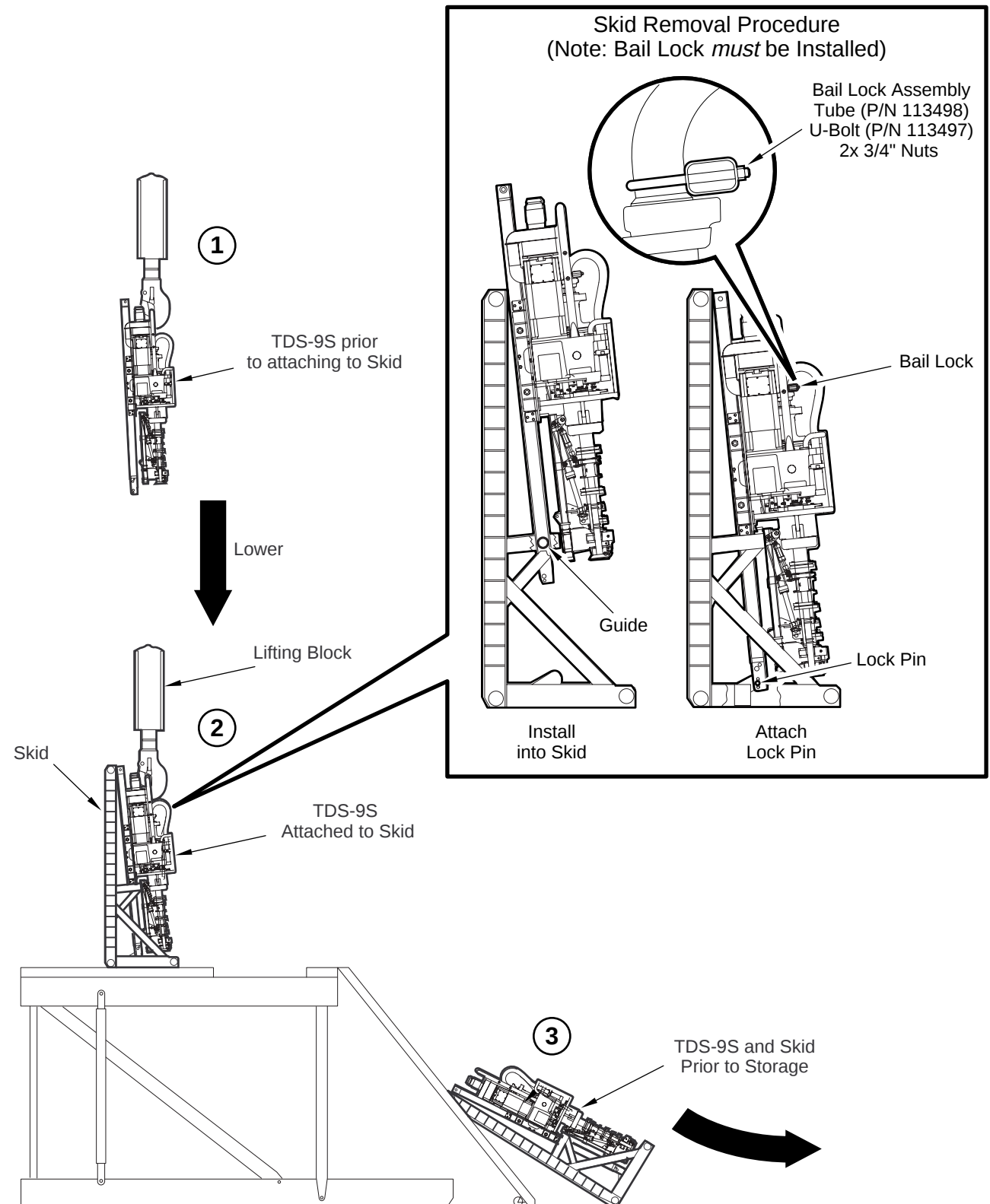
It is assumed that the Varco control panel, the Varco driller's console, and the frequency inverter are energized. For details on this equipment refer to the *TDS-9S Control System Service Manual*.

1. Operate each control on the driller's console. Refer to the *Operation* book for the console and functions.
2. Assign the cooling motors and inverter by selecting FORWARD or REVERSE on the Varco driller's console.
3. Rotate the drill stem using the THROTTLE on the Varco driller's console and observe operation.
4. Check for alarm conditions and resolve any alarms at this time.

# Long term TDS-9S storage procedures

---

1. Drain the oil from the gearbox prior to rigging down.
2. Remove the saver sub.
3. Disconnect guide beam from lower attachment and connecting link.
4. Rig down the guide beam.
5. Bring the shipping and handling skid to the drill floor.
6. Install the TDS-9S into the skid and pin (Figure 2-20).
7. Release the hook and remove the TDS-9S.
8. For indoor storage, cover the TDS-9S in its shipping and handling skid. A cargo container is appropriate for outdoor storage.
9. Avoid wide variations in temperature and high humidity. The preferred environment is clean and dry at 60°F ambient.
10. All exposed unpainted metal surfaces are coated with a rust preventive prior to shipment; however, check these surfaces periodically to be sure that no corrosion is taking place. The recommended rust preventive (slushing compound) for bare metal surfaces is Kendall Grade 5 (GE-D6C6A1) or equivalent.
11. Cover all openings to prevent water or dust from entering. Leave enough space around the drilling motors for ventilation. Do not use silica gel or a dehydrating agent.
11. During storage, rotate the motors and gear train periodically to distribute lubricant. Perform this at three month intervals if stored indoors, and at one month intervals if stored outdoors.
12. For long term storage recommendations dealing with the AC drilling motors, see the motor manufacturer's manual.



**Figure 2-20. Installing the TDS-9S into the skid**

# Returning the TDS-9S to service after storage

---

Before placing the TDS-9S back into service after storage, verify the following items:

1. Remove all rust preventive and any corrosion that may have taken place, taking special care with all load carrying components.
2. Follow the return to service procedures in the AC drilling motor manufacturer's manual.

## TDS-9S Installation checklist (FIP00003)

---

Use the checklist (FIP00003) on the following pages to rig up the TDS-9S.



| REVISIONS |             |                      |            |            |
|-----------|-------------|----------------------|------------|------------|
| LTR       | DESCRIPTION | PREPARED             | CHECKED    | APVD       |
| -         | DEV RELEASE | L. HONDON<br>3/28/96 | MM 3/28/96 | MM 3/28/96 |
|           |             |                      |            |            |
|           |             |                      |            |            |

Test Date \_\_\_\_\_

Cover 1-92

REVISIONS

DEL  
REV

DESCRIPTION

PREPARED

CHECKED

APVD

This document provides a procedure for checkout and testing of a TDS-9S Top Drive Drilling System installed on customers drilling rig.

| ITEM | INSTRUCTION                                                                                                       | VERIFIED | DATE  |
|------|-------------------------------------------------------------------------------------------------------------------|----------|-------|
| 1.   | Guide Beam Hang-Off Clevis secured with nuts and cotter pins.                                                     | _____    | _____ |
| 2.   | Guide Beam Hinge Pins secured with retainer pins.                                                                 | _____    | _____ |
| 3.   | Guide beam retainer pins secured with cotter pins                                                                 | _____    | _____ |
| 4.   | Guide Beam Tie-Back shimmed to well center.<br>Setback_____in.                                                    | _____    | _____ |
| 5.   | Measure distance from bottom of guide beam to drill floor.<br><br>Measurement:_____ft.                            | _____    | _____ |
| 6.   | Measure distance from center of RT to center of guide beam.<br><br>Measurement:_____ft.                           | _____    | _____ |
| 7.   | Lower attachment assembly properly fastened to the spreader beam, and guide beam.                                 | _____    | _____ |
| 8.   | Check that safety clips and shackles are properly installed.                                                      | _____    | _____ |
| 9.   | Guide Beam Tie-Back Bolts torqued and lock wired.                                                                 | _____    | _____ |
| 10.  | Guide Beam Tie-Back Pins secured with cotter pins.                                                                | _____    | _____ |
| 11.  | Carriage Guide Beam Lock Pins properly installed for drill position.                                              | _____    | _____ |
| 12.  | Guide Beam is clear of all mast obstructions.<br>i.e. girts, fastline, tugger lines, hang-off lines and brackets. | _____    | _____ |



TITLE

TDS-9S Field Installation  
Procedure

SIZE

A

SCALE

DOCUMENT NO.

FIP00003

SHEET

2 of 10

REVISIONS

DEL  
REV

DESCRIPTION

PREPARED

CHECKED

APVD

**ITEM INSTRUCTION**

**VERIFIED**

**DATE**

13. Measure Mud standpipe height:

Measurement: \_\_\_\_\_ ft from floor.

14. Derrick Service Loop Bracket installed at  
\_\_\_\_\_ ft from floor.

15. Electrical service loop installed and connections  
checked. Cables properly routed and supported  
in derrick and TDS.

16. Derrick service loop installed and connections  
checked. Cables properly routed and supported  
in derrick.

**CAUTION:** Do not at any time during installation or operation exceed the minimum  
bend radius of 40 in. for the electrical loops. Also, insure that the loop does not receive  
any axial torsion or twisting during installation or operation.

17. Mud hose and safety clamps properly installed.

18. Service loops and mud hose clear from obstacles  
such as stabbing board, cables, etc. over full  
TDS travel.

19. Service loop bracket clamp bars safety wired.

20. S-pipe and mud hose connections pressure tested  
against upper IBOP.

21. Service loop and mud hose not over-stressed  
or kinked with TDS at crown.

22. Upper IBOP made up to 60,000 ft lb. for 6-5/8"  
connection, using lead-based dope. **CAUTION:**  
Do not place tong in area of valve ball.



TITLE

TDS-9S Field Installation  
Procedure

SIZE

**A**

DOCUMENT NO.

FIP00003

SCALE

SHEET

3 OF 10

|                                                                                                                                        |                                                                                                                                                           | REVISIONS   |             |            |            |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------|------------|------------|--|--|
| DEL                                                                                                                                    | REV                                                                                                                                                       | DESCRIPTION | PREPARED    | CHECKED    | APVD       |  |  |
|                                                                                                                                        |                                                                                                                                                           |             | [Signature] | AM 3/28/96 | AM 3/28/96 |  |  |
| ITEM                                                                                                                                   | INSTRUCTION                                                                                                                                               | VERIFIED    | DATE        |            |            |  |  |
| 23.                                                                                                                                    | Lower IBOP valve and saver sub torqued to 60,000 ft lbs.<br>Part No. _____ Serial No. _____<br>Part No. _____ Serial No. _____                            | _____       | _____       |            |            |  |  |
| 24.                                                                                                                                    | Protruding tong die burrs removed from valves.                                                                                                            | _____       | _____       |            |            |  |  |
| 25.                                                                                                                                    | Tool joint connection clamp bolts torqued to 185 ft lbs.                                                                                                  | _____       | _____       |            |            |  |  |
| 26.                                                                                                                                    | PH50 clamp operating properly.                                                                                                                            | _____       | _____       |            |            |  |  |
| 27.                                                                                                                                    | Counterbalance pressure adjusted.<br>(pressure _____ psi).                                                                                                | _____       | _____       |            |            |  |  |
| <b>NOTE:</b> Explain importance of counterbalance system — stand jump, counterbalance, auto-return, and adjustment procedure to crews. |                                                                                                                                                           |             |             |            |            |  |  |
| 28.                                                                                                                                    | Blower motor rotation direction and current checked. R.H. _____ amps L.H. _____ amps                                                                      | _____       | _____       |            |            |  |  |
| 29.                                                                                                                                    | Oil pump motors rotation direction and current checked _____ amps                                                                                         | _____       | _____       |            |            |  |  |
| 30.                                                                                                                                    | Space heaters wired to ON whenever TDS is OFF.                                                                                                            | _____       | _____       |            |            |  |  |
| 31.                                                                                                                                    | Gear case filled with oil to middle of sight glass.                                                                                                       | _____       | _____       |            |            |  |  |
| 32.                                                                                                                                    | Hydraulic reservoir filled to middle of top sight glass.                                                                                                  | _____       | _____       |            |            |  |  |
| 33.                                                                                                                                    | All grease points lubed and pointed out to the crews. Refer to Service Manual Maintenance section for detail.                                             | _____       | _____       |            |            |  |  |
| 34.                                                                                                                                    | Hydraulic filter and lube oil filter checked and element replaced if necessary.<br><b>NOTE:</b> Indicator may need to be reset after the system warms up. | _____       | _____       |            |            |  |  |
| 35.                                                                                                                                    | Link tilt cylinder attachment clamps set at 45" from bottom of link eye to bottom of clamp.                                                               | _____       | _____       |            |            |  |  |

|                                                                                    |                                     |               |              |
|------------------------------------------------------------------------------------|-------------------------------------|---------------|--------------|
|  | TITLE                               | SIZE          | DOCUMENT NO. |
|                                                                                    | TDS-9S Field Installation Procedure | <b>A</b>      | FIP00003     |
|                                                                                    | SCALE                               | SHEET 4 of 10 |              |

|      |                                                                                                                                                                         | REVISIONS  |             |          |         |         |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------|----------|---------|---------|
|      |                                                                                                                                                                         | DEL<br>REV | DESCRIPTION | PREPARED | CHECKED | APVD    |
|      |                                                                                                                                                                         |            |             | 3/28/96  | 3/29/96 | 3/29/96 |
| ITEM | INSTRUCTION                                                                                                                                                             | VERIFIED   | DATE        |          |         |         |
| 36.  | IBOP cranks secured, bolts properly torqued and safety lock tabs properly installed.                                                                                    | _____      | _____       |          |         |         |
| 37.  | Upper IBOP open when actuator shell is down. Closed when up.                                                                                                            | _____      | _____       |          |         |         |
| 38.  | All cable connectors properly installed, terminals tight and J-Boxes properly closed.                                                                                   | _____      | _____       |          |         |         |
| 39.  | Start power unit and check for satisfactory operation in conjunction with other equipment. Check for unusual noises.                                                    | _____      | _____       |          |         |         |
| 40.  | Drill/Spin/Torque functions operating properly.                                                                                                                         | _____      | _____       |          |         |         |
| 41.  | Maximum Drill Current _____ amps.<br>Ramp Time: Up _____ sec. Down _____ sec.<br>Spin Speed _____ RPM<br>Spin Torque _____ ft lbs.<br>Maximum Torque Current _____ amps | _____      | _____       |          |         |         |
| 42.  | Torque Ramp UP/DOWN abort functioning.                                                                                                                                  | _____      | _____       |          |         |         |
| 43.  | Correct RPM and torque readout.                                                                                                                                         | _____      | _____       |          |         |         |
| 44.  | Driller's console control checks completed satisfactorily. Any discrepancies noted and discussed with customer.                                                         | _____      | _____       |          |         |         |
| 45.  | Top Drive Control System Function Checks completed satisfactorily.                                                                                                      | _____      | _____       |          |         |         |
| 46.  | Top Drive Control Systems Interlock Checks completed satisfactorily.                                                                                                    | _____      | _____       |          |         |         |
| 47.  | Top Drive Control System Alarm Checks completed satisfactorily.                                                                                                         | _____      | _____       |          |         |         |
| 48.  | IBOP open timer operating.<br>(approx. 30 to 45 sec.)                                                                                                                   | _____      | _____       |          |         |         |

|                                                                                    |                                        |               |              |
|------------------------------------------------------------------------------------|----------------------------------------|---------------|--------------|
|  | TITLE                                  | SIZE          | DOCUMENT NO. |
|                                                                                    | TDS-9S Field Installation<br>Procedure | A             | FIP00003     |
|                                                                                    | SCALE                                  | SHEET 5 of 10 |              |

REVISIONS

DEL  
REV

DESCRIPTION

PREPARED

CHECKED

APVD

The undersigned representatives hereby acknowledge that all checkout and testing work, as listed herein, has been successfully completed for this Top Drive Drilling System. This acknowledgment is sufficient for initiation of Varco's warranty coverage and for approval for payment of any invoices for equipment, effective the date listed below. This acknowledgment in no way relieves Varco of its responsibility for equipment and workmanship with respect to this top drive drilling system.

\_\_\_\_\_  
Varco Representative

\_\_\_\_\_  
Effective Date

\_\_\_\_\_  
Customer Representative



TITLE

TDS-9S Field Installation  
Procedure

SIZE

**A**

DOCUMENT NO.

FIP00003

SCALE

SHEET 6 of 10

|            |             |                     |                    |
|------------|-------------|---------------------|--------------------|
| REVISIONS  |             |                     |                    |
| DEL<br>REV | DESCRIPTION | PREPARED<br>3/28/96 | CHECKED<br>3/28/96 |
|            |             | APPROVED<br>3/28/96 |                    |

### Drive Control System Function Checks

| Function                          | Switch Position                                    | Indicator Display Lamp | Physical Check                                 | Check OK |
|-----------------------------------|----------------------------------------------------|------------------------|------------------------------------------------|----------|
| Blowers                           | Forward<br>Reverse<br>Off                          | N/A                    | Blowers On<br>Blowers On<br>Blowers Off        |          |
| Oil Pump                          | Forward<br>Reverse<br>Off                          | N/A                    | Oil Pump On<br>Oil Pump On<br>Oil Pump Off     |          |
| IBOP                              | Closed<br><br>Open                                 | On<br><br>Off          | Actuator Shell Up<br>Actuator Shell Down       |          |
| Link Tilt                         | Drill<br>Off<br>Tilt                               | N/A<br>N/A<br>N/A      | Links Retract<br>No Movement<br>Links Extended |          |
| Link Tilt Float                   | Push<br><br>Release                                | N/A<br><br>N/A         | Links Float to W/C<br>Links Hold Position      |          |
| Rotating Head (Manual)            | Left<br>Right                                      | N/A<br>N/A             | Rotates Left<br>Rotates Right                  |          |
| Rotating Head (Auto Return)       | On<br><br>Off                                      | N/A<br><br>N/A         | Returns to Auto Set Point<br>Holds Position    |          |
| Rotating Head (Auto Position Set) | After rotating to desired position.<br>Push to set | On                     | Auto Return Position Selected                  |          |
| Counter Balance                   | Drill<br><br>Stand Jump                            | N/A<br><br>N/A         | Balance TDS Weight<br>Lifts TDS Wt.            |          |

REVISIONS

DEL  
REV

DESCRIPTION

PREPARED

CHECKED

APVD

Top Drive Control System Function Checks

| Function                 | Switch Position                                    | Indicator Display Lamp              | Physical Check                                                            | Check OK |
|--------------------------|----------------------------------------------------|-------------------------------------|---------------------------------------------------------------------------|----------|
| Brake                    | Off<br>On<br>Auto/Throttle On<br>Auto/Throttle Off | Off<br>On<br>Off<br>On              | Brake Released<br>Brake Set<br>Brake Released<br>Brake Set                |          |
| Torque Wrench            | Off<br><br>Clamp(Push)                             | N/A<br><br>N/A                      | Shot Pin Disengaged & Jaws Unclamped.<br>Shot Pin Engaged & Jaws Clamped. |          |
| Alarm Silence Lamp Check | Push<br>Push                                       | On (Steady)<br>On (After 2 seconds) | Horn Silenced<br>All Lamps on (After 2 seconds)                           |          |

Top Drive Control System Interlock Checks

| Function            | Control Sequence                                                                                                                                                                  | Action                                                                           | Check OK |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------|
| Rotating Head       | With links in tilt or drill position, actuate rotate left/right<br><br>With links in tilt or drill position, actuate float push button. After 5 seconds actuate rotate left/right | No rotation<br><br>Links float toward W/C. After 5 seconds rotating head rotates |          |
| Torque Wrench Clamp | With drill/spin/ torque switch in drill mode and throttle on, actuate torque wrench clamp.                                                                                        | No torque wrench clamp                                                           |          |



TITLE

TDS-9S Field Installation  
Procedure

SIZE

A

DOCUMENT NO.

FIP00003

SCALE

SHEET

8 of 10



REVISIONS

DEL  
REV

DESCRIPTION

PREPARED BY

CHECKED BY

APVD BY

Top Drive Control System Alarm Checks

| Alarm Function                  | Action to Initiate                             | Display Indication                         | Check OK |
|---------------------------------|------------------------------------------------|--------------------------------------------|----------|
| Oil Pressure Loss               | Remove/Cap Oil Press Line to Oil Press Switch  | "Oil Pressure" Illuminates and Horn Sounds |          |
|                                 | Trip Oil Pump Starter                          | "Oil Pressure" Illuminates and Horn Sounds |          |
| Blower Differential Press Right | Remove Line to Right Differential Press Switch | "Blower Loss" Illuminates and Horn Sounds  |          |
|                                 | Trip Right Blower Starter                      | "Blower Loss" Illuminates and Horn Sounds  |          |
| Blower Differential Press Left  | Remove Line to Left Differential Press Switch  | "Blower Loss" Illuminates and Horn Sounds  |          |
|                                 | Trip Left Blower Starter                       | "Blower Loss" Illuminates and Horn Sounds  |          |



TITLE

TDS-9S Field Installation  
Procedure

SIZE

A

DOCUMENT NO.

FIP00003

SCALE

SHEET

9 of 10

Date: \_\_\_\_\_ Owner: \_\_\_\_\_ Rig Identity No./Name: \_\_\_\_\_ Page No.: \_\_\_\_\_

Unit No.: \_\_\_\_\_ Rig Type: \_\_\_\_\_ Initial Location: \_\_\_\_\_ Reporter: \_\_\_\_\_

| REVISIONS  |             |                     |                     |                     |  |
|------------|-------------|---------------------|---------------------|---------------------|--|
| DEL<br>REV | DESCRIPTION | PREPARED            | CHECKED             | APVD                |  |
|            |             | [Signature] 3/28/96 | [Signature] 3/28/96 | [Signature] 3/28/96 |  |
|            |             |                     |                     |                     |  |
|            |             |                     |                     |                     |  |
|            |             |                     |                     |                     |  |



## TDS-9S Field Installation Procedure

SCALE

FIP00003

SHEET 10 OF 10

---

**TDS-9S**

**Top Drive  
Drilling  
System**

**Operation**

---

March 9, 1998

# Contents

## Chapter 1 Varco Driller's Console

## Chapter 2 Operating procedures

|                                                    |      |
|----------------------------------------------------|------|
| Start-up procedure .....                           | 3-9  |
| Pipehandler operation .....                        | 3-12 |
| Rotating link adapter .....                        | 3-12 |
| IBOP safety valves .....                           | 3-12 |
| Torque backup clamp .....                          | 3-14 |
| Link tilt .....                                    | 3-14 |
| Tool joint locks.....                              | 3-17 |
| Torque values for load carrying components .....   | 3-17 |
| Changing drill string sizes .....                  | 3-18 |
| Drilling ahead .....                               | 3-18 |
| Drilling ahead with triples .....                  | 3-18 |
| Drilling ahead with singles .....                  | 3-22 |
| Tripping .....                                     | 3-25 |
| Reaming out .....                                  | 3-26 |
| Well control procedures .....                      | 3-28 |
| Running casing .....                               | 3-32 |
| Post jarring operations .....                      | 3-33 |
| Post jarring checklist/design torque standard..... | 3-33 |

March 9, 1998

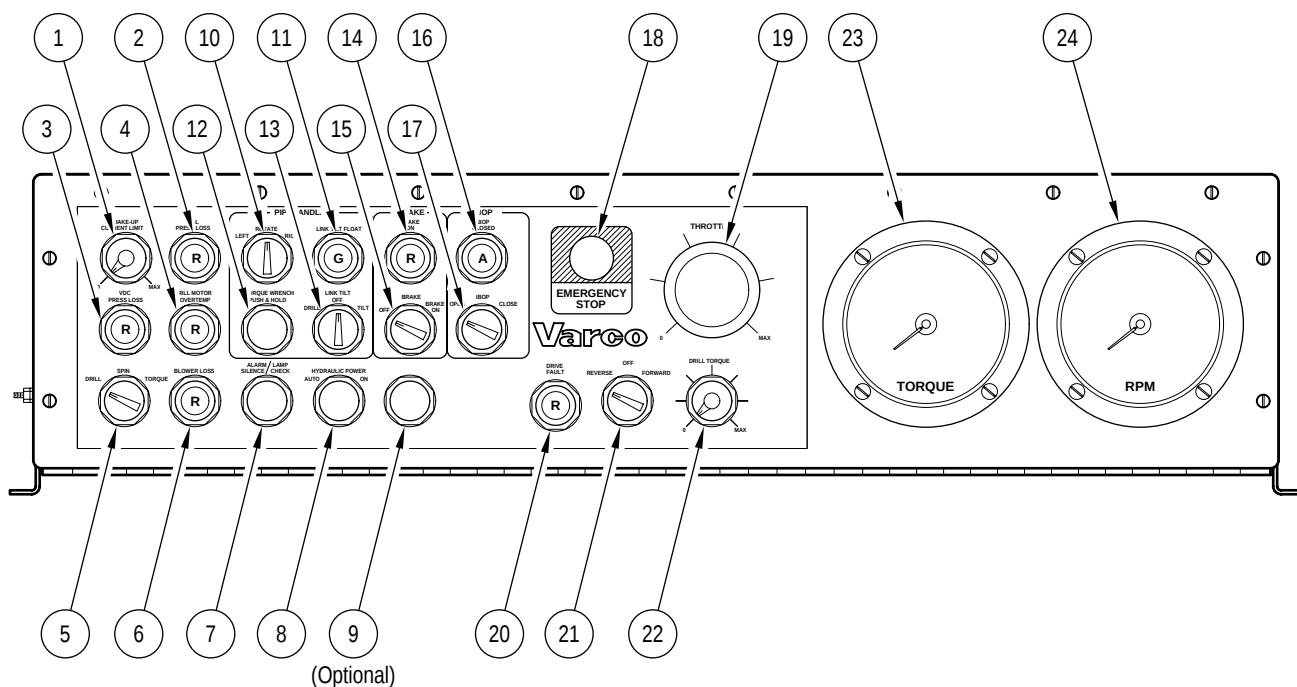
# Chapter 1

## Varco Driller's Console



Refer to the *Control System Service Manual* for additional operation information.

The stainless steel Varco Driller's Console (VDC) is waterproof and purgable. The console's front panel drops down to allow access to components. Table 3-1 identifies and describes VDC components.



**Figure 3-1. Typical Varco Driller's Console (VDC)**

**Table 3-1. Varco driller's console**

| Ref. | Name                                         | Type                       | Function                                                                                                                                                                                                                                                                                                                                                  |
|------|----------------------------------------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1    | <b>MAKE-UP<br/>CURRENT LIMIT:</b><br>0 ⇒ MAX | Potentiometer              | Sets current limit in VFD during makeup operations. This sets the maximum allowable makeup connection torque. The torque is adjusted by setting the brake and adjusting MAKE-UP CURRENT LIMIT potentiometer to increase or decrease the torque as indicated on the TORQUE meter.                                                                          |
| 2    | <b>OIL PRESS LOSS</b>                        | Red indicator              | Indicator flashes and horn sounds when an oil pressure loss is detected in the gearcase lubrication system. Pressing the ALARM SILENCE push-button turns off the alarm whereas the indicator remains on until the fault is cleared.                                                                                                                       |
| 3    | <b>VDC PRESS LOSS</b>                        | Red indicator              | Indicator flashes and horn sounds when a loss of purge pressure in the VDC is detected. Pressing the ALARM SILENCE push-button turns off the alarm whereas the indicator remains on until the fault is cleared.                                                                                                                                           |
| 4    | <b>DRILL MOTOR<br/>OVERTEMP</b>              | Red indicator              | Indicator flashes and horn sounds when an overtemperature condition is detected in a drilling motor. Pressing the ALARM SILENCE push-button turns off the alarm whereas the indicator remains on until the fault is cleared.                                                                                                                              |
| 5    | <b>DRILL/SPIN/<br/>TORQUE</b>                | 3-Position selector switch | DRILL position selects the normal drilling mode with the rotational speed controlled by the THROTTLE and the maximum torque controlled by the DRILL TORQUE potentiometer. SPIN mode is a fixed speed mode. TORQUE mode is the makeup mode. In the torque mode, torque increases gradually up to the limit set by the MAKE-UP CURRENT LIMIT potentiometer. |
| 6    | <b>BLOWER LOSS</b>                           | Red indicator              | Indicator flashes and horn sounds when a blower fault is detected. Pressing the ALARM SILENCE push-button turns off the alarm whereas the indicator remains on until the fault is cleared.                                                                                                                                                                |



**Table 3-1. Varco driller's console (continued)**

| Ref. | Name                                                                                                                                                                            | Type                                        | Function                                                                                                                                                                                                                                                                                                                                                                                 |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7    | <b>ALARM SILENCE/<br/>LAMP CHECK</b>                                                                                                                                            | Pushbutton switch                           | <p>When pressed while the alarm horn is sounding, silences the horn. However, the fault indicator that caused the alarm to sound remains lit until the fault is cleared or reset. If the fault is not cleared within 5 minutes, the alarm horn sounds again.</p> <p>When this switch is pressed and held for 2 seconds, it lights all of the indicators on the VDC for a lamp check.</p> |
| 8    | <b>HYDRAULIC<br/>POWER<br/>AUTO/ON</b>                                                                                                                                          | 2-Position switch                           | When set to AUTO, turns on hydraulic pump when commanded by the PLC. When set to ON, turns on hydraulic pump regardless of operating mode.                                                                                                                                                                                                                                               |
| 9    | <b>COUNTERBALANCE<br/>DRILL/STAND<br/>JUMP</b><br>(This is an optional switch. When switch is not included, counterbalance actuators function as they would in DRILL position.) | 2-Position switch                           | <p>In DRILL position, counterbalance actuators receive enough pressure to counterbalance weight of the TDS.</p> <p>In STAND JUMP position, counterbalance actuators receive enough pressure to lift the TDS in order to separate drill pipe connection as it unscrews.</p>                                                                                                               |
| 10   | <b>(PIPEHANDLER)<br/>ROTATE<br/>LEFT/RIGHT</b>                                                                                                                                  | 3-Position momentary switch with center off | When held in LEFT position, rotates head to the left. When held in RIGHT position, rotates head to the right. Switch automatically returns to center (off) position when released.                                                                                                                                                                                                       |
| 11   | <b>(PIPEHANDLER)<br/>LINK TILT FLOAT</b>                                                                                                                                        | Green lighted pushbutton                    | The links "float" to the center (neutral) position when push-button is pressed .                                                                                                                                                                                                                                                                                                         |
| 12   | <b>(PIPEHANDLER)<br/>TORQUE WRENCH<br/>PUSH &amp; HOLD</b>                                                                                                                      | Pushbutton switch                           | When pressed and held, engages pipe clamp and shot pin lock.                                                                                                                                                                                                                                                                                                                             |
| 13   | <b>(PIPEHANDLER)<br/>LINK TILT<br/>DRILL/OFF/TILT</b>                                                                                                                           | 3-Position maintained switch                | When set to DRILL, link tilt cylinders are retracted to place the head in the normal drilling position. When set to TILT, link tilt cylinders are extended to tilt the head for makeup operations. When set to OFF, the head remains in its present position.                                                                                                                            |
| 14   | <b>BRAKE ON</b>                                                                                                                                                                 | Red indicator                               | Indicator lights to indicate the brake is on when the brake solenoid is energized.                                                                                                                                                                                                                                                                                                       |
| 15   | <b>BRAKE<br/>OFF/AUTO/ON</b>                                                                                                                                                    | 3-Position switch                           | When set to ON, brake solenoid is energized to set the brakes and light the BRAKE ON indicator. When set to AUTO, brake is released when THROTTLE is advanced and is set when THROTTLE is turned off. When set to OFF, brake is released.                                                                                                                                                |

**Table 3-1. Varco driller's console (continued)**

| <b>Ref.</b> | <b>Name</b>                        | <b>Type</b>            | <b>Function</b>                                                                                                                                                                                                                                                        |
|-------------|------------------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>16</b>   | <b>IBOP CLOSED</b>                 | Amber indicator        | Lights when hydraulic pressure is applied to the cylinder that closes the IBOP valve.                                                                                                                                                                                  |
| <b>17</b>   | <b>IBOP<br/>OPEN/CLOSE</b>         | 2-Position<br>switch   | OPEN position extends the actuator cylinder to open the IBOP valve. CLOSE position retracts the actuator cylinder to close IBOP the valve.                                                                                                                             |
| <b>18</b>   | <b>EMERGENCY STOP</b>              | Mushroom<br>pushbutton | When pressed, shuts down all operations. The switch is hardwired to the VFD and when pressed, deselects the VFD regardless of the throttle position. However, the auxiliary cooling motors remain on.                                                                  |
| <b>19</b>   | <b>THROTTLE:</b><br>0 ⇒ MAX        | Potentiometer          | Controls speed of drilling motors. The resulting drill pipe speed is displayed on the RPM meter.                                                                                                                                                                       |
| <b>20</b>   | <b>DRIVE FAULT</b>                 | Red indicator          | Indicator flashes and horn sounds when a VDC fault is detected. Pressing the ALARM SILENCE push-button turns off the alarm whereas the indicator remains on until the fault is cleared.                                                                                |
| <b>21</b>   | <b>REVERSE/OFF/<br/>FORWARD</b>    | 3-Position<br>switch   | Controls direction of rotation of the drilling motors in both drilling and makeup modes of operation.                                                                                                                                                                  |
| <b>22</b>   | <b>DRILL TORQUE:</b><br>0 ⇒ MAX    | Potentiometer          | Sets current limit in VFD during drilling operations. This sets the maximum allowable drill pipe torque. The torque is adjusted by setting the brake and adjusting the DRILL TORQUE potentiometer to increase or decrease the torque as indicated on the TORQUE meter. |
| <b>23</b>   | <b>TORQUE:</b><br>0 ⇒ 50,000 ft/lb | Meter<br>(0 - 10 VDC)  | Displays drill pipe torque in ft lb. In drilling mode, torque is set by DRILL TORQUE potentiometer and in makeup mode, by MAKE-UP CURRENT LIMIT potentiometer.                                                                                                         |
| <b>24</b>   | <b>RPM:</b><br>0 ⇒ 250 rpm         | Meter<br>(0 - 10 VDC)  | Displays drill pipe rotational speed in rpm. Rotational speed is controlled by the THROTTLE control.                                                                                                                                                                   |

# Chapter 2

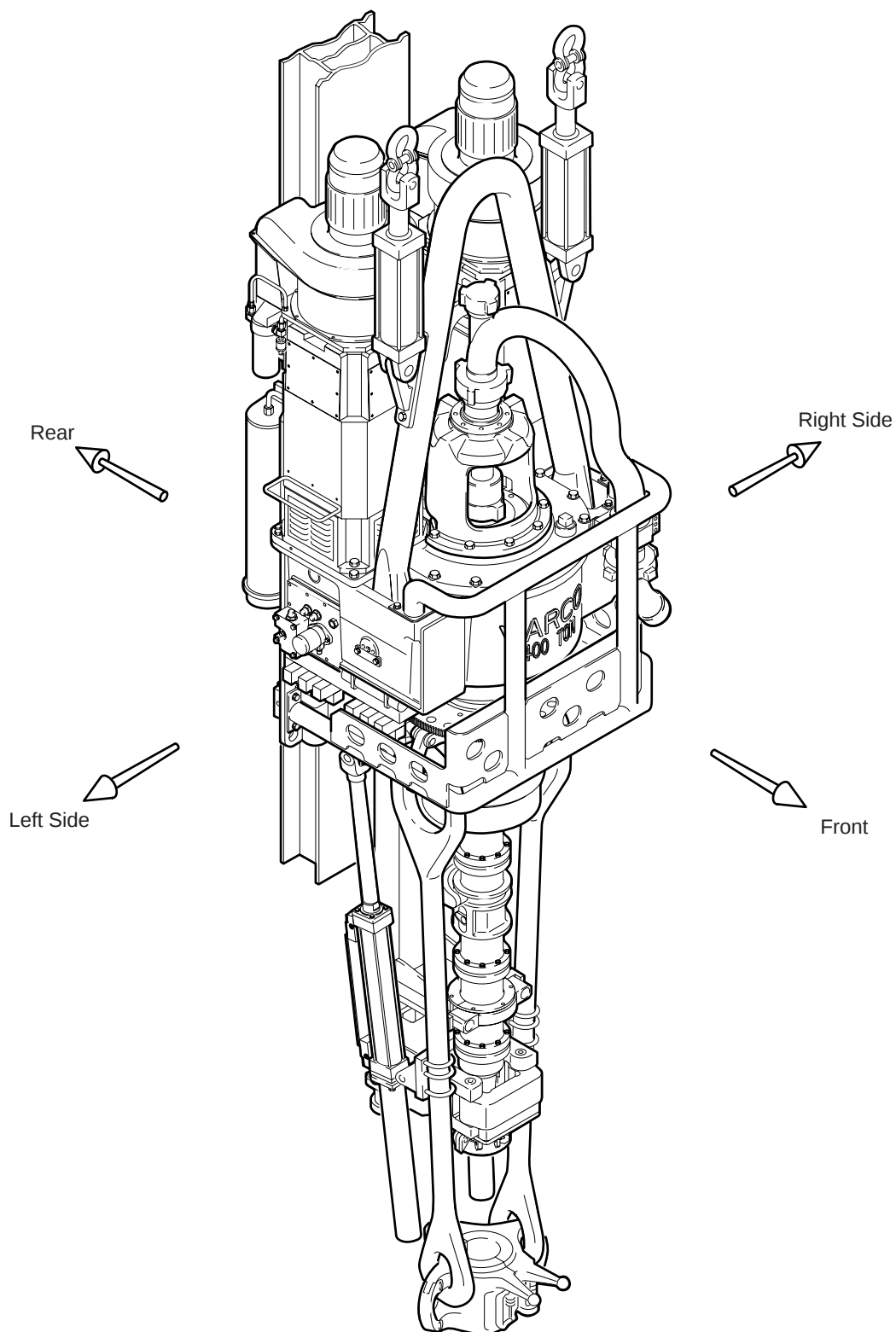
## Operating procedures

### Start-up procedure

---



TDS-9S orientation is described in Figure 3-2.



**Figure 3-2. TDS-9S Orientation**

Use the following procedures to start up the TDS-9S:

1. Check the lubrication level on the sight gauge in the main body.
2. Check the hydraulic fluid level on the sight gauge in the reservoir.
3. Assign the top drive to FORWARD, throttle OFF, DRILL TORQUE LIMIT set to half scale. The blowers and hydraulic pump start.
4. Check the hydraulic filter indicator located on the filter mounted on the left AC drilling motor.



The indicator may be out because the fluid is cold. Reset the indicator and check its status after the hydraulic system is warmed up.

5. Check the lube filter indicator.
6. With the top drive near the drill floor, exercise each control on the VDC.
7. Rotate the drive shaft.

# Pipehandler operation

---



Hydraulic system adjustments for link tilt operation (mousehole adjustment and drill down adjustment) are described in the link tilt circuit description and schematic located in the troubleshooting section of the *Maintenance and Troubleshooting* book.

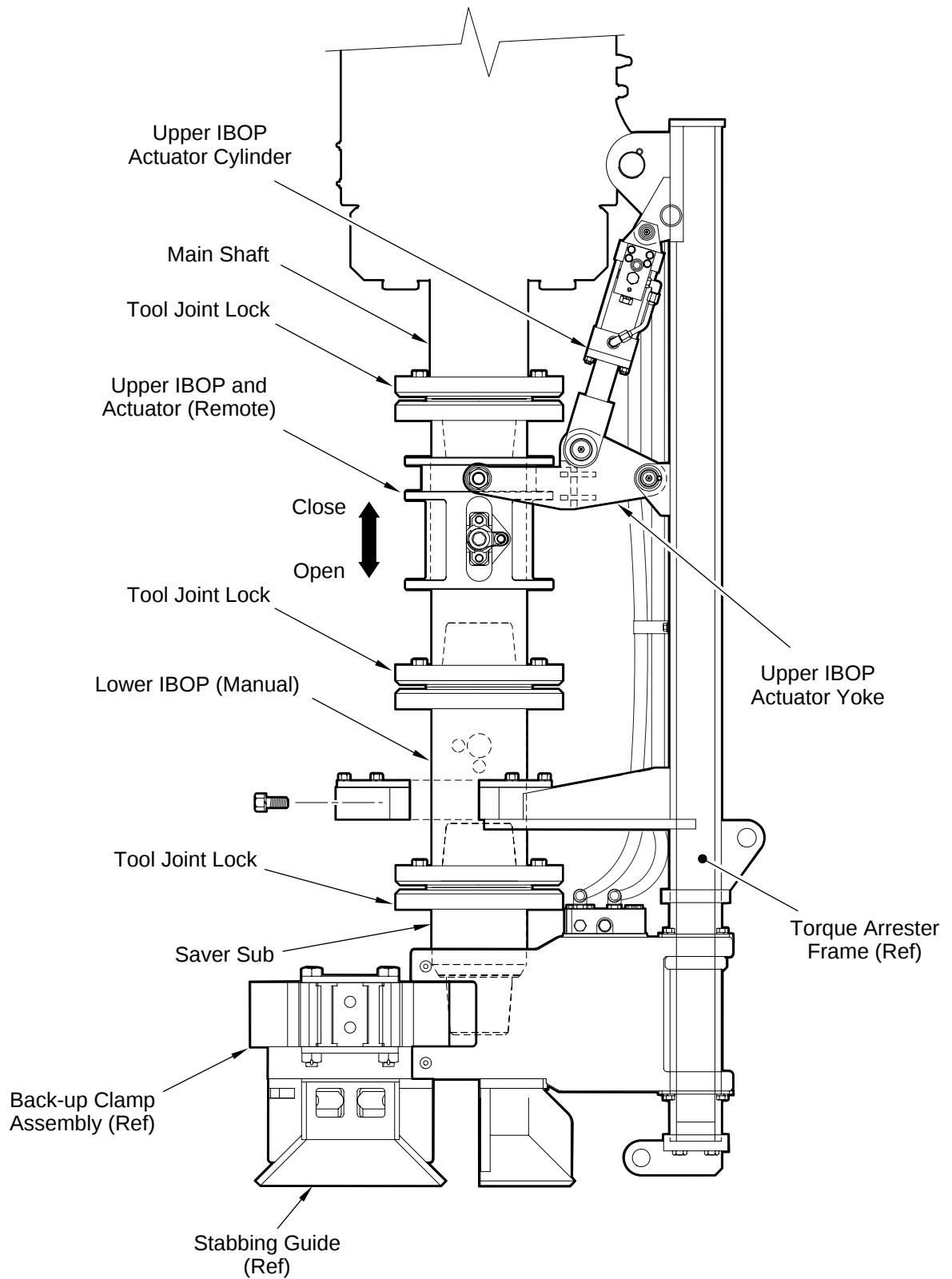
## Rotating link adapter

The rotating link adapter supports the weight of the drill string through a set of links that hang from the adapter. The positioning gear is an integral part of the rotating link adapter. The positioning gear, meshed with a hydraulic motor driven pinion gear, rotates the pipehandler. The rotating link adapter also functions as a hydraulic slip ring providing all the necessary hydraulic passages between the stationary load stem and the rotating link adapter.

## IBOP safety valves

Turning the IBOP switch on the VDC to the CLOSE position retracts the hydraulic actuator cylinder rod, moving the yoke and the actuator shell body upward (Figure 3-3). This upward movement rotates the crank assemblies 90°, closing the IBOP ball valve.

Turning the switch to the OPEN position extends the cylinder rod, pushing the IBOP actuator shell downward, opening the IBOP. Full hydraulic pressure is applied to fully open the valve, then a hydraulic timing circuit reduces the pressure maintaining the shell position.



**Figure 3-3. IBOP safety valve actuator system**

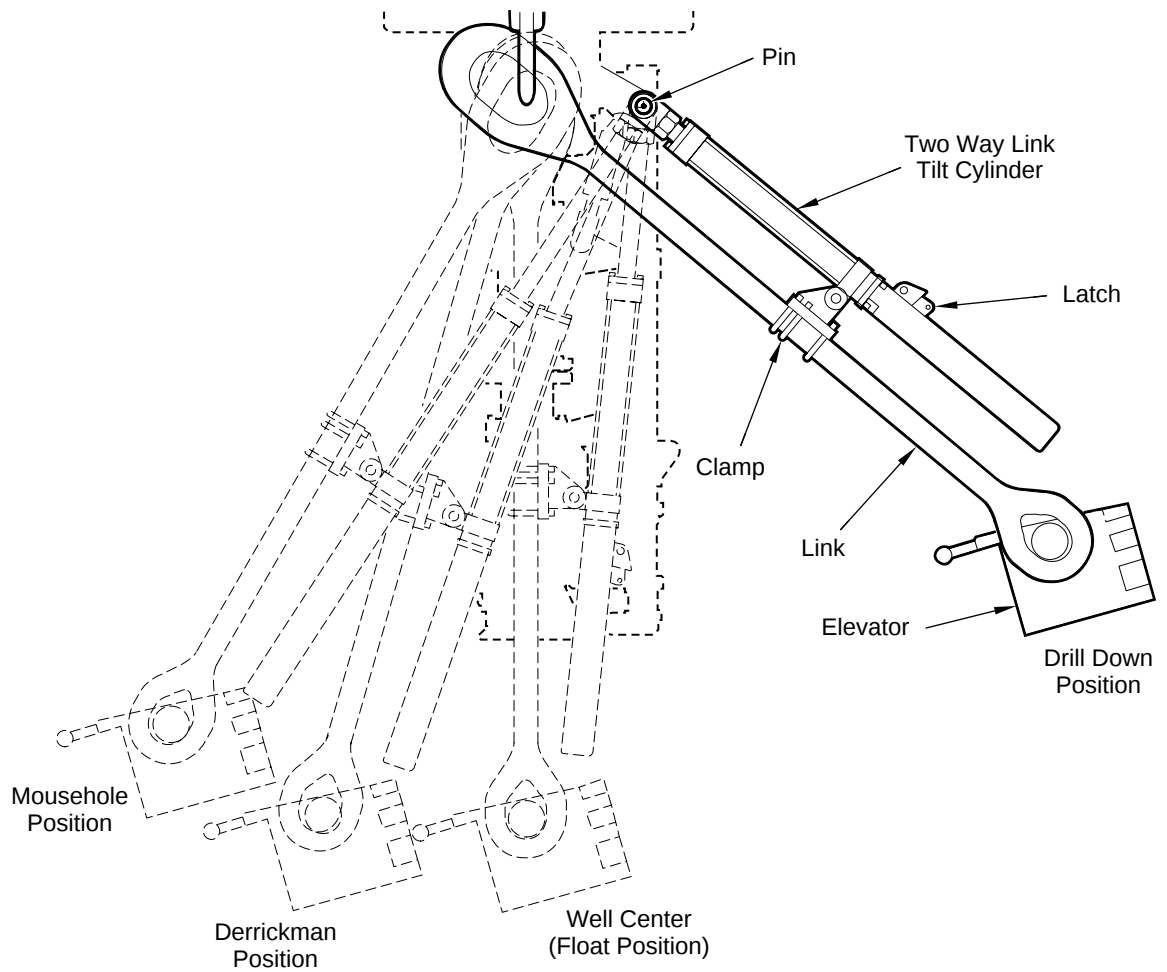
## **Torque backup clamp**

The pipehandler clamp cylinder has two jaw assemblies that clamp on the box section of a tool joint when the shot pin is fully engaged in the rotating link adapter positioning gear. Pushing the torque wrench clamp switch rotates the link adapter slowly until the shot pin engages. With the shot pin fully engaged, the torque backup clamp jaws clamp onto the tool joint. With the tool joint held in place by the clamp cylinder, the AC drilling motors make or break connections.

## **Link tilt**

The link tilt consists of two double-rod assemblies with the upper rod pinned to the rotating link adapter and lower end of the cylinder pinned to the elevator links (Figure 3-4). Turning the link tilt switch on the VDC to the right extends the drill pipe elevator to the derrickman position. The latch on the cylinder assembly limits the elevator travel to the derrickman position. Pulling the latch cable on each cylinder releases the latch, allowing the elevator to travel to the mousehole position.





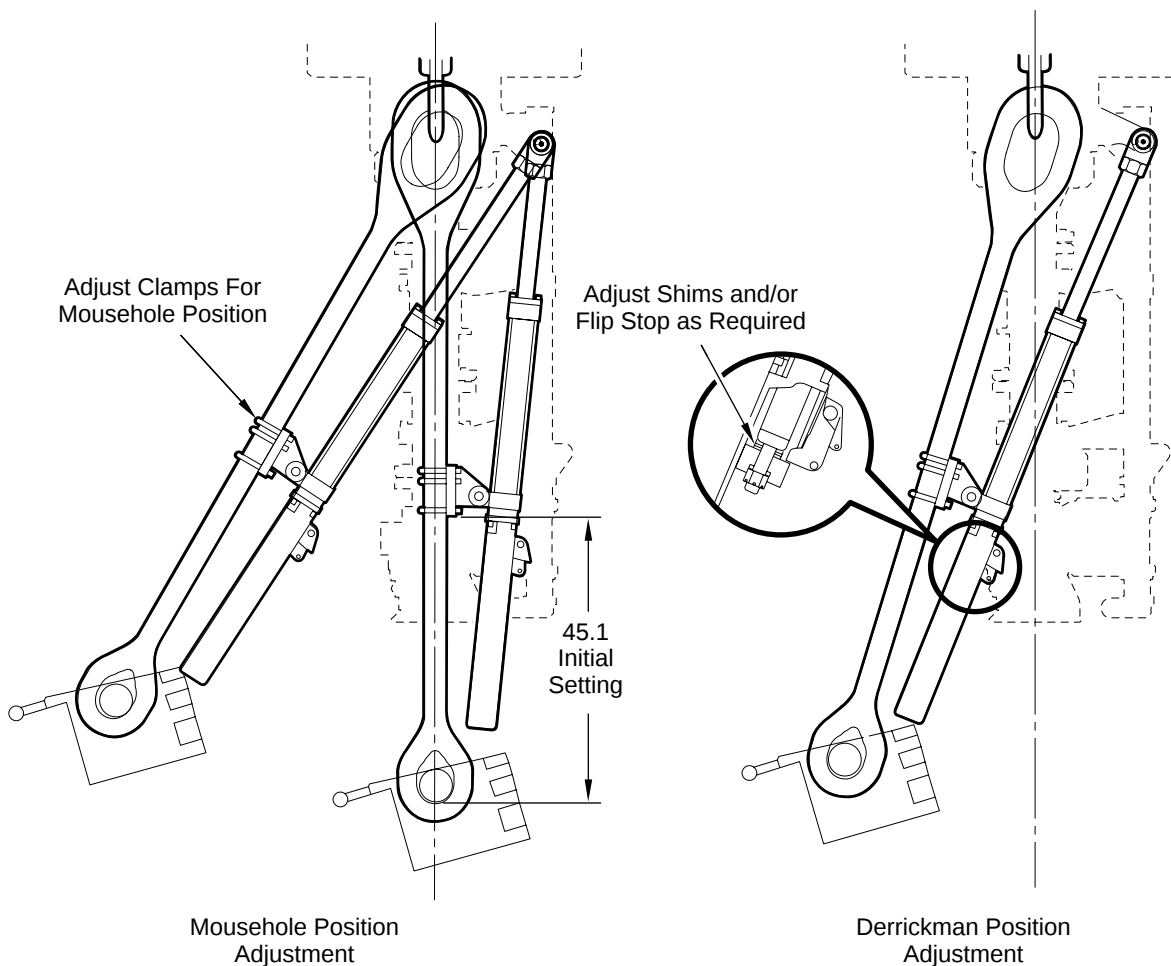
**Figure 3-4. Link tilt**

Turning the link tilt switch to the left retracts the drill pipe elevator to the drill down position. Pushing the link tilt float button allows the elevator to return to well center.

Elevator travel is adjustable to the derrickman and mousehole positions.

To adjust the derrickman position, adjust the shims and/or flip stop as required at the end of the cylinders (Figure 3-5).

The initial mousehole setting should be 45 in. from the bottom of the link clamps to the bottom of the link eyes. If it is necessary to adjust the mousehole position, relocate the clamps on the links as required.



**Figure 3-5. Link tilt adjustments**

## Tool joint locks

Three tool joint locks are installed over the joints to prevent inadvertent breakout between the main shaft, upper IBOP, lower IBOP and saver sub. Each of these locking assemblies consists of an inner double tapered split sleeve and two external rings. Tightening the bolts draw the two external rings together over the split internal sleeve providing the locking force (Figure 3-3).

Factory tests demonstrate that a tool joint lock properly installed can resist a torque of up to 30,000 ft lb. A 6 5/8 in. API connection made up to 46,000 ft lb can resist a net torque of 76,000 ft lb. See *Installing the tool joint lock* in the *Installation* book for additional information.

## Torque values for load carrying components

Proper makeup torque is critical to the function of drill stem components. Table 3-2 only includes components within the TDS-9S. Refer to the API charts for other components.

**Table 3-2. Torque values for load carrying components**

| Components                                 | ID    | Connection         | OD        | Min. torque  | Max. torque* |
|--------------------------------------------|-------|--------------------|-----------|--------------|--------------|
| Upper safety valve to main stem/main shaft | 3 in. | 6 5/8 in. API Reg. | 7 3/8 in. | 46,000 ft lb | 63,000 ft lb |
| Lower safety valve to upper safety valve   | 3 in. | 6 5/8 in. API Reg. | 7 3/8 in. | 46,000 ft lb | 63,000 ft lb |
| Saver sub to lower safety valve            | 3 in. | 6 5/8 in. API Reg. | 7 3/8 in. | 46,000 ft lb | 63,000 ft lb |
| Crossover sub to lower safety valve        | 3 in. | 6 5/8 in. API Reg. | 7 3/8 in. | 46,000 ft lb | 63,000 ft lb |

\* Maximum +10%.

## Changing drill string sizes

To run drill string sizes that are different from the size specified on your rig's original configuration, install a separate drill string handling kit which is available for the PH-50 (Table 3-3).

**Table 3-3. Drill string kit chart**

| Part number | Saver sub |
|-------------|-----------|
| 114543      | HT40      |
| 114852      | NC26      |
| 97471       | NC31      |
| 80534-501   | NC38      |
| 114092      | NC40      |
| 78656-3     | NC46      |
| 76666-4     | NC50      |

## Drilling ahead

---

### Drilling ahead with triples

Drilling ahead with triples is the common drilling mode for the TDS-9S. There are various sources for triples. On skidding rigs drilling multiple well platforms, drill pipe can be left racked and used to drill the next well.

If triples do not currently exist, there are two recommended methods of obtaining them. One is to leave some triples racked in the derrick when tripping back in the hole and finish the trip with singles. Leave enough triples racked to handle anticipated bit life.

The second method for obtaining triples is to make up triples in the mousehole while drilling ahead or during idle rig time. For safety reasons, a pivoting mousehole is best because it can pivot to a vertical plane to simplify making connections.

Use the following procedure to drill ahead with triples (Figure 3-6):

1. Drill down until the saver sub is within three feet of the rotary table.
2. Circulate bottoms up as necessary.

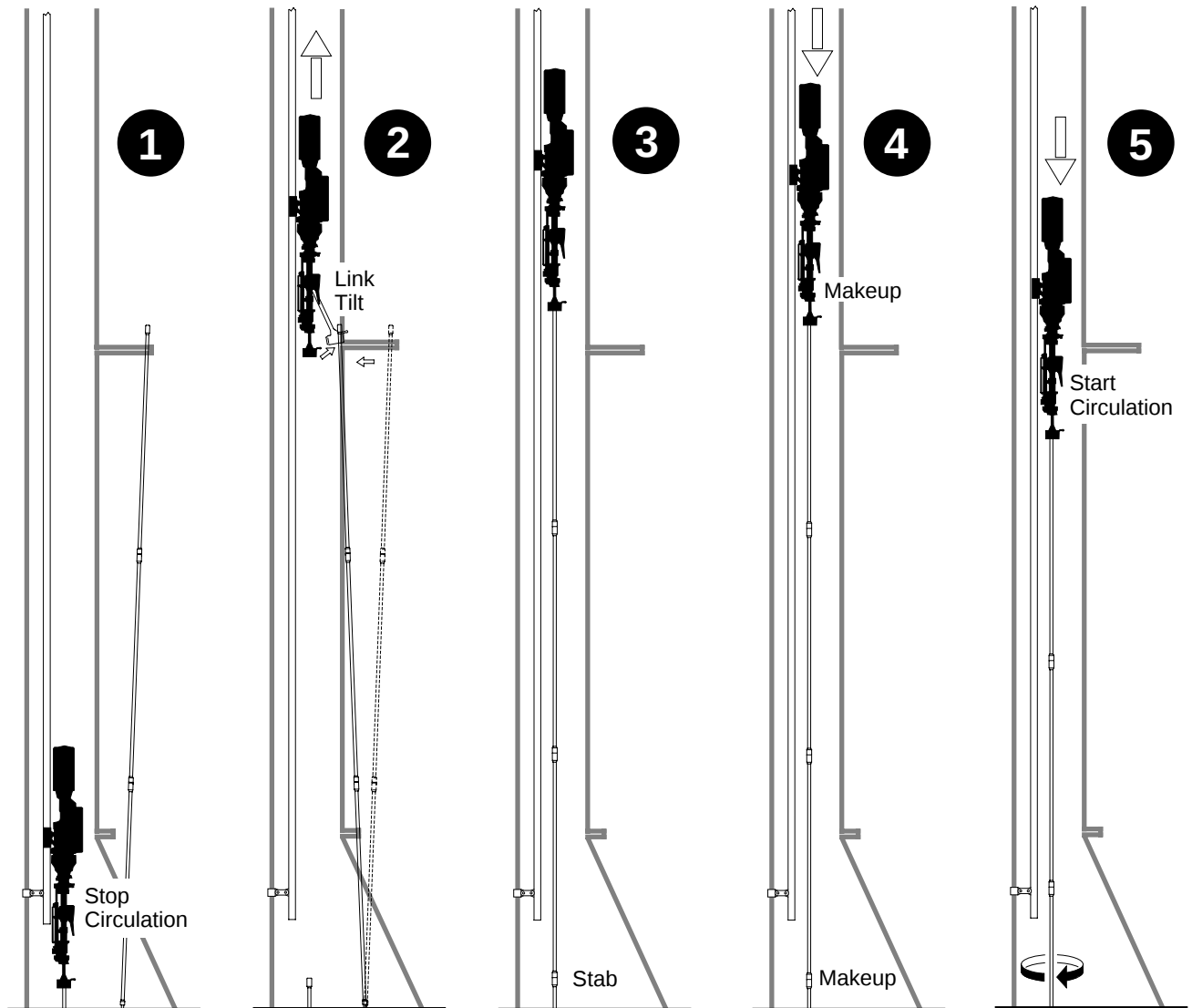
- Set slips on string
- Stop circulation
- Breakout connection using pipehandler and drilling motor (in reverse)

- Raise block
- Tilt link tilt to derrickman

- Pickup stand with elevator
- Stab bottom of stand onto string

- Lower block to stab motor into top of stand
- Spin in motor and stand
- Makeup both connections with motor

- Pull slips
- Start circulation
- Begin drilling



**Figure 3-6. Drilling ahead with triples**

3. Stop the string rotation.
4. Pick up the string and set the slips for a connection four feet off the rig floor.
5. Switch the TDS-9S motors from FORWARD to REVERSE.
6. Stop the mud pumps.
7. Close the upper IBOP.
8. Set the brake to AUTO.
9. Clamp the pipehandler on the drill pipe.
10. Set the TDS-9S mode to TORQUE and release the switch. When the connection is broken out, return the TDS-9S mode switch to DRILL.
11. Using the TDS-9S drill motors, spin out of the box while hoisting the TDS-9S with the drawworks (follow with the drawworks, do not lead), or energize stand jump mode, if installed. Stand jump lifts the top drive off the hook as the pipe unscrews.
12. Stop the spin out mode. De-energize stand jump, if installed.
13. Open the drill pipe elevator.
14. Hoist the TDS-9S away from the hole and tilt the links/ elevator toward the derrickman position.
15. Hoist the TDS-9S to the racking board level to get the next stand.
16. Latch the backup tong on the box connection.
17. Thoroughly dope the box connection in the rotary table.
18. Switch the TDS-9S motor from REVERSE to FORWARD.
19. Latch the elevator on the next stand.
20. Hoist the pin off the setback area and clear the box with the stand.
21. Release the link tilt.
22. Stab the connection at the floor.
23. Switch the TDS-9S to SPIN mode.

24. Continue to slack off approximately two feet to stab the upper connection of the stand with the TDS-9S.
25. Slack off to allow connection to shoulder up (lead with the drawworks, do not follow).
26. Switch to TORQUE and hold for approximately ten seconds. The makeup torque must be preset.
27. Verify full makeup to the correct value on the torque meter.
28. Switch to DRILL mode.
29. Unlatch the backup tong.
30. Open the IBOP.
31. Start the mud pumps.
32. Pick up to pull the slips.
33. Drill ahead.

## Drilling ahead with singles

Typically, there are two situations requiring drilling ahead with singles. One is beginning operations on a new well where there are no triples made up and racked. The other is when making surveys every 30 feet (kicking off using a downhole mud motor.) The link tilt feature moves the elevators to the mousehole to pick up the singles.

Use the following procedure to drill ahead with singles (Figure 3-7):

1. Drill down to the existing single, pull up to the four foot level (approximately), and set the slips.



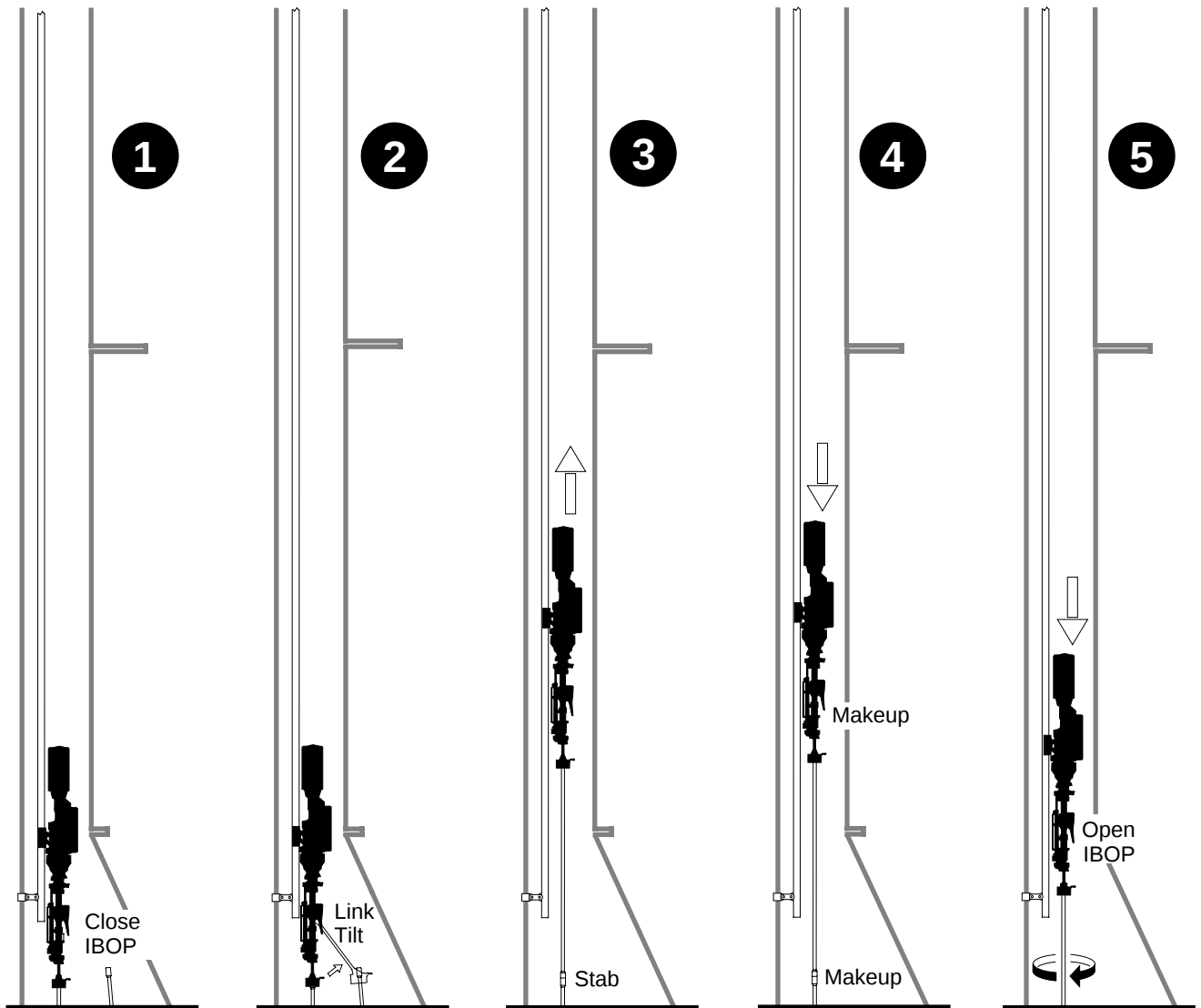
- Set slips on string
- Stop circulation
- Close IBOP
- Breakout connection using pipehandler and drilling motor (in reverse)

- Tilt links to mousehole
- Latch drill pipe elevator around single

- Pickup single with elevator
- Release link tilt
- Stab bottom of single onto string

- Lower block to stab motor into top of single
- Spin in motor and single
- Makeup both connections with motor in torque mode

- Pull slips
- Open IBOP
- Start circulation
- Begin drilling



**Figure 3-7. Drilling ahead with singles**

2. Break the connection between the saver sub and the drill pipe using the TDS-9S drilling motors in the TORQUE mode; reverse.
3. Spin out the connection using the drilling motor in the SPIN mode.
4. Lift the TDS-9S with the elevators open.
5. Use the link tilt to bring the elevator over to the single in the mousehole and latch the elevator around the single.
6. Pull the single out of the mousehole, and as the pin clears the floor, release the link tilt to allow the single to come to well center.
7. Stab the connection at the floor and lower the TDS-9S, allowing the added single to enter the stabbing guide until the saver sub pin stabs into the box of the new joint.
8. Using a backup tong to react the torque, spin up using the SPIN mode and torque the connection using the TDS-9S motors in the TORQUE mode.
9. Pull the slips, start the mud pumps, and drill ahead.

# Tripping

---

Perform tripping operations in the conventional manner.

If a tight spot or key seat is encountered while tripping out of the hole, spin the drilling motor into the stand at any height in the derrick. Establish circulation and rotation immediately to work the pipe through the tight spot.

# Reaming out

---

Use the following procedure to ream out of the hole (Figure 3-8):

1. Hoist the block while circulating and rotating the drill string until the third connection appears.
2. Stop circulation and rotation and set the slips.
3. Break out the drilling motor from the top of the stand using the TDS-9S drilling motors. Hold a backup at the floor and spin out the drilling motor.
4. Break out the stand at floor level, and spin out using pipe spinners.
5. Pick up the stand with the drill pipe elevator.
6. Rack the stand back.
7. Lower the block and TDS-9S to the floor.
8. Stab the drilling motor into the box, spin up and torque it with the drilling motor with the clamp cylinder jaws clamped onto the box.
9. Resume circulation and continue reaming out of the hole.

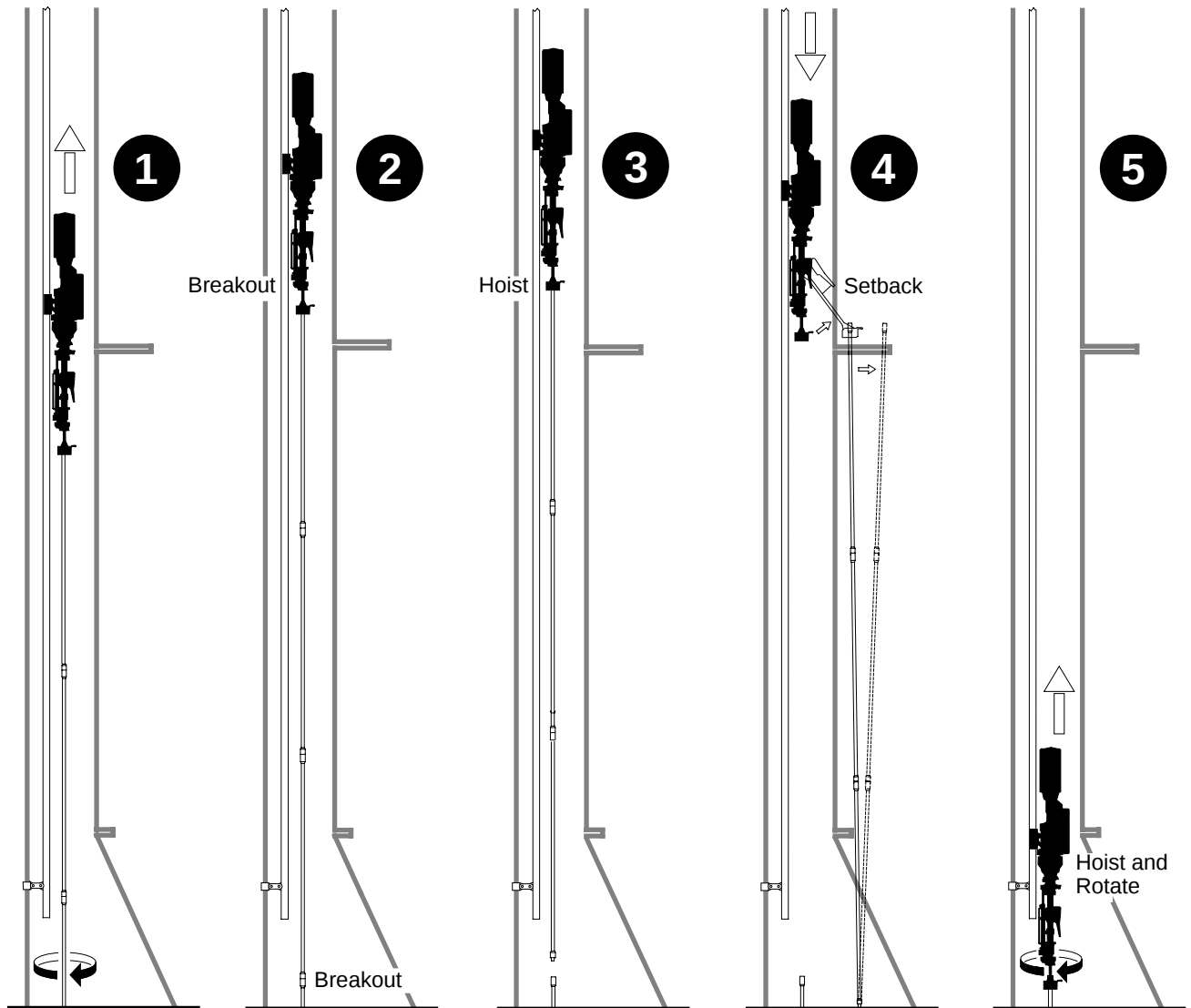
- Hoist while circulating and rotating
- When 3-rd connection surfaces, stop rotation and circulation

- Set slips on string
- Breakout connection using pipehandler and drilling motor (reverse)
- Breakout and spinout stand at floor

- Hoist free stand with elevator

- Setback stand using link tilt

- Lower block, stab motor into string
- Spin in motor and makeup connection with motor
- Start circulation, pull slips, hoist and rotate



**Figure 3-8. Reaming out**

# Well control procedures

---

The TDS can stab into the string in any position in the derrick. While drilling, the remotely controlled upper IBOP valve is always in the string for immediate use.

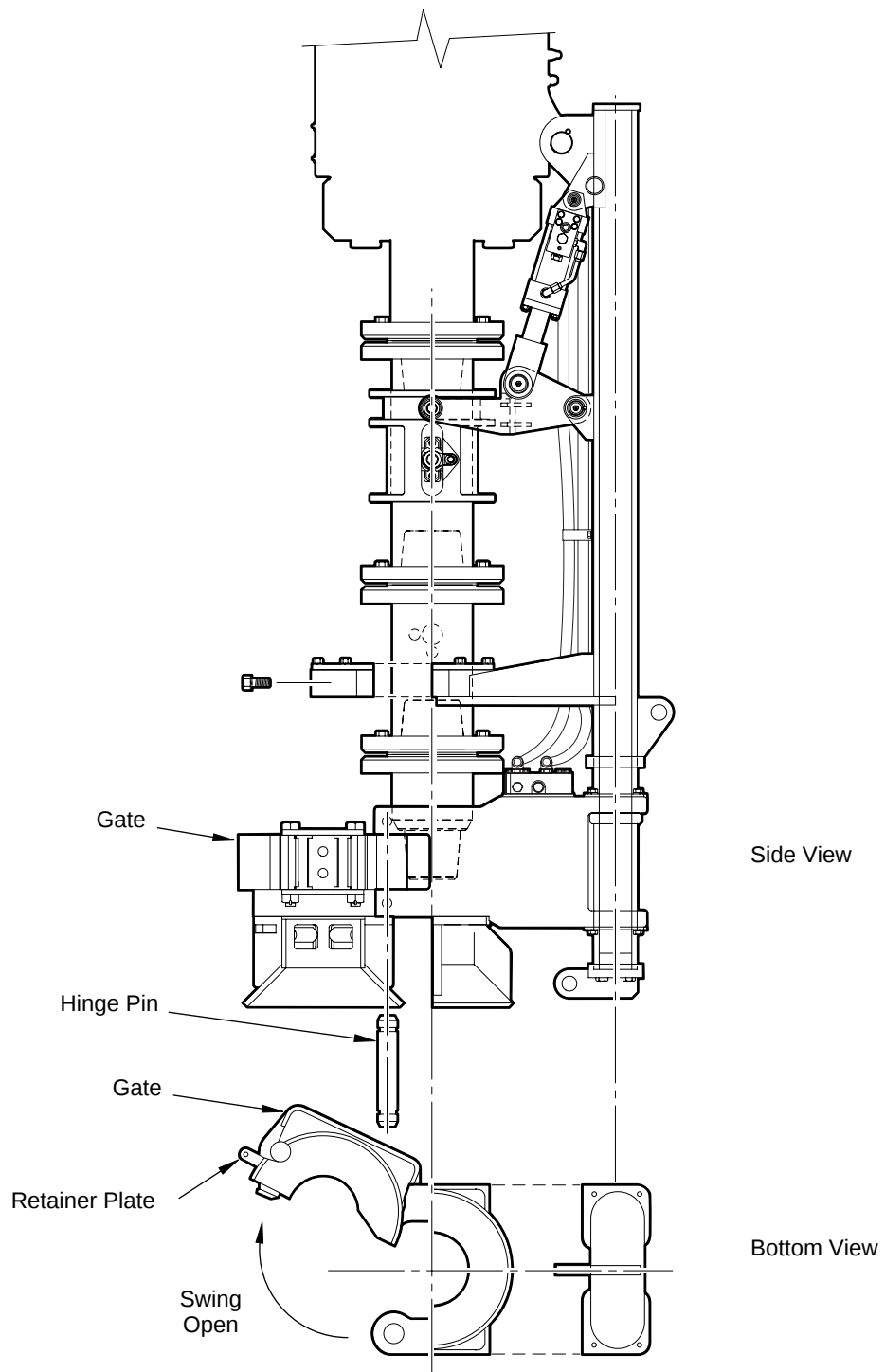
Use the following TDS-9S well control procedure in conjunction with standard IBOP well control procedures:

1. On indication of a kick, set the slips at the nearest connection and stab the TDS-9S into the string.
2. Spin up and torque the connection using the spin/torque control, after setting the backup tong.
3. Remotely close the upper IBOP valve. Operation of the safety valves is the same as any standard valve.



A 7/8 in. hex wrench is included with the system to operate the upper valve if the remote actuator fails).

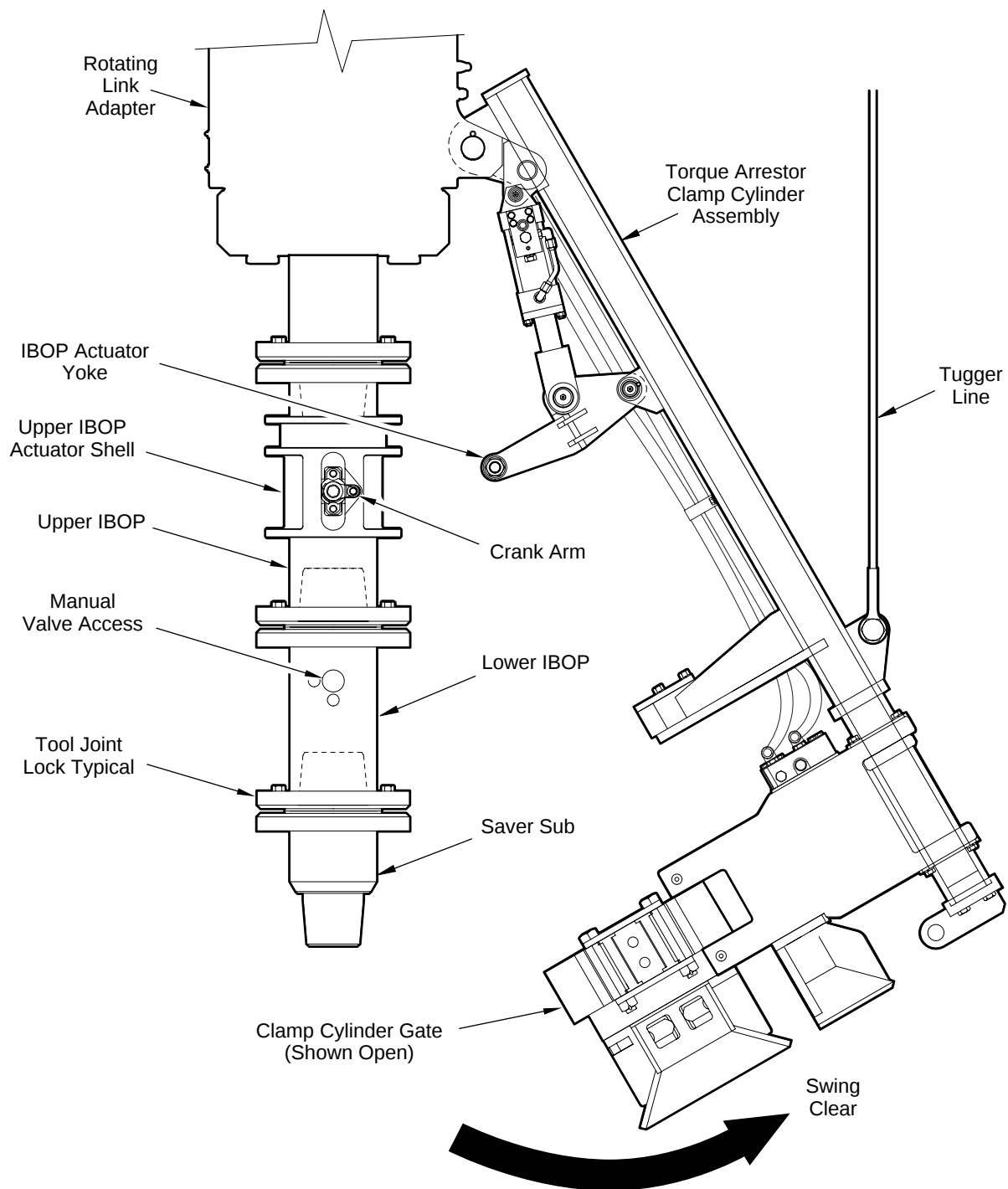
4. Lower the string to the floor and reset the slips.
5. Manually close the lower IBOP valve.
6. Remove the retainer plate screw in the stabbing guide under the backup clamp right hinge pin. Swing the retainer plate out and slide the hinge pin through the bottom (Figure 3-9). Swing the gate open.
7. Remove the two bolts (with slotted nuts and cotter pins) that hold the stabilizer assembly halves together.



**Figure 3-9. Torque backup clamp**

8. Using a tugger line, swing the torque arrestor out of the way so you can install the tongs (Figure 3-10).
9. Remove the two lower tool joint locks.
10. Breakout the lower IBOP from the upper IBOP using tongs.
11. Engage the drive motors in reverse to spin out the connection.
12. Install the appropriate crossover sub, check valve, or circulation sub on top of lower IBOP valve.





**Figure 3-10. Well control procedures**

# Running casing

---

For casing operations, longer elevator links (180 in.) must be used to allow clearance for the cementing head under the torque wrench in the pipehandler.

Attach a short piece of hose to the saver sub in the pipehandler to fill the casing while lowering. Use the remotely controlled upper IBOP valve to start and stop the fluid flow.

If desired, run casing conventionally using the block and hook and swinging the TDS aside. Use longer bails (180 in.) to prevent the block dolly (if used) from contacting the TDS dolly.

# Post jarring operations

---



*Jarring occurs on all drilling rigs. It is not practical to recommend removing the top drive from the drill string during all jarring operations. But the possibility of damage to a top drive during a jarring operation is considerable. Consider removing the top drive from the drill string before performing prolonged jarring. It is imperative to exercise caution when using a top drive after a jarring operation.*

*Safe operation of the top drive is the responsibility of the user and crew. Use the Post Jarring Checklist and Design Specification, Design Torque Standard (DS00008) to help ensure top drive operation. Note that the checklist includes recommended procedures. Do not limit inspections to items on the checklist.*

*The checklist draws attention to specific parts on major subassemblies. Inspection should be rigorous, looking for any wear that could cause a safety or operational risk.*

## Post jarring checklist/design torque standard

Use the checklist and Design Torque Standard (DS00008) on the following pages after performing any jarring operation while the top drive is in the drill string.

March 9, 1998

### POST JARRING CHECKLIST

#### TOP DRIVE DRILLING SYSTEMS

| <u>DESIGNATION / ITEM</u>                         | <u>OK</u> | <u>COMMENTS</u> |
|---------------------------------------------------|-----------|-----------------|
| <b><u>Elevators</u></b>                           |           |                 |
| Link Block Bolt Assemblies Secured                | _____     |                 |
| Hinge Pin retainer in Place                       | _____     |                 |
| Latch Pin Retainer in Place                       | _____     |                 |
| <b><u>Pipe Handler</u></b>                        |           |                 |
| Guard Pin Secured                                 | _____     |                 |
| Bell Guide Bolts Secured                          | _____     |                 |
| Hinge Pin Retainer Bolts Inspect                  | _____     |                 |
| Die Retainer Bolts Secured                        | _____     |                 |
| Jaw Retaining Bolts Tight                         | _____     |                 |
| Torque Wrench Mounting Bolts Secured              | _____     |                 |
| Bolts On Die Spring Covers Secured                | _____     |                 |
| Pins for Die Springs Secured                      | _____     |                 |
| Lift Cylinder Pins Secured                        | _____     |                 |
| Torque Cylinder/Torque Tube Secured               | _____     |                 |
| Hanger Nuts for IBOP Cylinders Secured            | _____     |                 |
| Hanger Pin for Pipe Handler/Rotating Head Secured | _____     |                 |
| <b><u>IBOP Actuator</u></b>                       |           |                 |
| Bolts for Crank Assembly Secured                  | _____     |                 |
| Roller Assembly Bolts Secured                     | _____     |                 |
| Actuator Arm Pins Secured                         | _____     |                 |
| <b><u>Dolly Assembly</u></b>                      |           |                 |
| Bolts for Dolly Roller Brackets Secured           | _____     |                 |
| Bolts for Service Loop Clamp Bars Secured         | _____     |                 |
| Bolts for S/Pipe Clamp Secured                    | _____     |                 |
| Bolts for Swivel Link Retainer Plates Secured     | _____     |                 |
| Quill Housing Trunion Cap Bolts Secured           | _____     |                 |
| Swing Bolt Pins/Nuts Secured                      | _____     |                 |
| <b><u>Motor / Quill Assembly</u></b>              |           |                 |
| Junction Box Mounting Bolts Secured               | _____     |                 |
| Inspect Junction Box Feet                         | _____     |                 |
| Blower Motor Mounting Feet Bolts Secured          | _____     |                 |
| Heat Exchanger Mounting Bolts Secured             | _____     |                 |
| Counterbalance Cylinder Pins Secured              | _____     |                 |
| Counterbalance Shackles Secured                   | _____     |                 |

### DESIGNATION / ITEM

OK

COMMENTS

#### Torque Arrestors

All Bolts for Solid Body Elevator Plate Secured  
Torque Arrestors/Mounting Pins at  
Rotating Head Secured

\_\_\_\_\_  
\_\_\_\_\_

#### Link Tilt

Shackle Secured  
Mounting Bolts Secured to Solid Body Elevator  
Check Mounting Feet on Link Tilt Frame  
Stop Adjustment Pins or Lock Nuts Secured  
Pivot Pin Secured

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

#### Gear Box

Alignment Cylinder Pins Secured  
Auto Return Cylinder Pins Secured

\_\_\_\_\_  
\_\_\_\_\_

#### Cooling System

Extended Intake Inlet Mounting Bolts  
Remote Blower Snorkle Tube Saddle Bolts

\_\_\_\_\_  
\_\_\_\_\_

| REVISIONS |             |           |          |      |
|-----------|-------------|-----------|----------|------|
| LTR       | DESCRIPTION | PREPARED  | CHECKED  | APVD |
| -         | DEV RELEASE | A. Vargas | B. Levay | JB   |
| A         | SEE DCN     | L. Rondou | JPSJ     | RKA  |
| B         | SEE DCN     | L. Rondou | JPSJ     | BLS  |

[illegible]

| TORQUE VALUES FOR LIGHT MACHINE OIL LUBRICATED BOLTS                                 |                                      |                                                                                     |             |                                         |                                                                                       |             |
|--------------------------------------------------------------------------------------|--------------------------------------|-------------------------------------------------------------------------------------|-------------|-----------------------------------------|---------------------------------------------------------------------------------------|-------------|
| JPSJ                                                                                 | GRADE 2                              |                                                                                     |             | GRADE 5                                 |                                                                                       |             |
| 31-Mar-92                                                                            | T.S. = 74,000 PSI TO 3/4" DIA        |                                                                                     |             | T.S. = 120,000 PSI TO 1" DIA            |                                                                                       |             |
|                                                                                      | PROOF STRENGTH = 55,000 PSI          |                                                                                     |             | PROOF STRENGTH = 85,000 PSI             |                                                                                       |             |
|                                                                                      | T.S. = 60,000 PSI 7/8" to 1-1/2" DIA |                                                                                     |             | T.S. = 105,000 PSI 1-1/8" to 1-1/2" DIA |                                                                                       |             |
|                                                                                      | PROOF STRENGTH = 33,000 PSI          |                                                                                     |             | PROOF STRENGTH = 74,000 PSI             |                                                                                       |             |
| COARSE THREAD SERIES - UNC                                                           |                                      |                                                                                     |             |                                         |                                                                                       |             |
| Dia-Threads                                                                          | MIN. TORQUE                          | MAX. TORQUE                                                                         | CLAMP FORCE | MIN. TORQUE                             | MAX. TORQUE                                                                           | CLAMP FORCE |
| Per Inch                                                                             | (ft-lbf)                             | (ft-lbf)                                                                            | (lb)        | (ft-lbf)                                | (ft-lbf)                                                                              | (lb)        |
| 1/4 - 20                                                                             | 5.7                                  | 6.3                                                                                 | 1,320       | 7.6                                     | 8.4                                                                                   | 2,020       |
| 5/16 - 18                                                                            | 10.5                                 | 11.6                                                                                | 2,160       | 16                                      | 18                                                                                    | 3,340       |
| 3/8 - 16                                                                             | 19                                   | 21                                                                                  | 3,200       | 29                                      | 32                                                                                    | 4,940       |
| 7/16 - 14                                                                            | 29                                   | 32                                                                                  | 4,380       | 48                                      | 53                                                                                    | 6,800       |
| 1/2 - 13                                                                             | 48                                   | 53                                                                                  | 5,840       | 71                                      | 79                                                                                    | 9,050       |
| 9/16 - 12                                                                            | 67                                   | 74                                                                                  | 7,500       | 105                                     | 116                                                                                   | 11,600      |
| 5/8 - 11                                                                             | 95                                   | 105                                                                                 | 9,300       | 143                                     | 158                                                                                   | 14,400      |
| 3/4 - 10                                                                             | 166                                  | 184                                                                                 | 13,800      | 247                                     | 273                                                                                   | 21,300      |
| 7/8 - 9                                                                              | 157                                  | 173                                                                                 | 11,400      | 409                                     | 452                                                                                   | 29,400      |
| 1 - 8                                                                                | 238                                  | 263                                                                                 | 15,000      | 608                                     | 672                                                                                   | 38,600      |
| 1 1/8 - 7                                                                            | 333                                  | 368                                                                                 | 18,900      | 760                                     | 840                                                                                   | 42,300      |
| 1 1/4 - 7                                                                            | 475                                  | 525                                                                                 | 24,000      | 1,064                                   | 1,176                                                                                 | 53,800      |
| 1 3/8 - 6                                                                            | 627                                  | 693                                                                                 | 28,600      | 1,387                                   | 1,533                                                                                 | 64,100      |
| 1 1/2 - 6                                                                            | 827                                  | 914                                                                                 | 34,800      | 1,843                                   | 2,037                                                                                 | 78,000      |
| FINE THREAD SERIES - UNF                                                             |                                      |                                                                                     |             |                                         |                                                                                       |             |
| 1/4 - 28                                                                             | 5.7                                  | 6.3                                                                                 | 1,500       | 9.5                                     | 10.5                                                                                  | 2,320       |
| 5/16 - 24                                                                            | 11.4                                 | 12.6                                                                                | 2,400       | 18                                      | 20                                                                                    | 3,700       |
| 3/8 - 24                                                                             | 22                                   | 24                                                                                  | 3,620       | 33                                      | 37                                                                                    | 5,600       |
| 7/16 - 20                                                                            | 33                                   | 37                                                                                  | 4,900       | 52                                      | 58                                                                                    | 7,550       |
| 1/2 - 20                                                                             | 52                                   | 58                                                                                  | 6,600       | 86                                      | 95                                                                                    | 10,700      |
| 9/16 - 18                                                                            | 76                                   | 84                                                                                  | 8,400       | 114                                     | 126                                                                                   | 12,950      |
| 5/8 - 18                                                                             | 105                                  | 116                                                                                 | 10,600      | 162                                     | 179                                                                                   | 16,300      |
| 3/4 - 16                                                                             | 185                                  | 205                                                                                 | 15,400      | 285                                     | 315                                                                                   | 23,800      |
| 7/8 - 14                                                                             | 176                                  | 194                                                                                 | 12,600      | 447                                     | 494                                                                                   | 32,400      |
| 1 - 14                                                                               | 257                                  | 284                                                                                 | 16,400      | 665                                     | 735                                                                                   | 42,200      |
| 1 1/8 - 12                                                                           | 380                                  | 420                                                                                 | 21,200      | 836                                     | 924                                                                                   | 47,500      |
| 1 1/4 - 12                                                                           | 523                                  | 578                                                                                 | 26,600      | 1,178                                   | 1,302                                                                                 | 59,600      |
| 1 3/8 - 12                                                                           | 703                                  | 777                                                                                 | 32,500      | 1,596                                   | 1,764                                                                                 | 73,000      |
| 1 1/2 - 12                                                                           | 931                                  | 1029                                                                                | 39,100      | 2,090                                   | 2,310                                                                                 | 87,700      |
| BOLT I.D.                                                                            |                                      |  |             |                                         |  |             |
| 1) VALUES ARE BASED ON LIGHT MACHINE OIL LUBRICATED BOLTS (NOT HIGH-PRESSURE LUBES). |                                      |                                                                                     |             |                                         |                                                                                       |             |
| 2) VARCO DOES NOT RECCOMEND ASSEMBLING BOLTS DRY.                                    |                                      |                                                                                     |             |                                         |                                                                                       |             |
| 3) PROOF STRENGTH IS APPROX 92% OF MINIMUM 'YIELD' STRENGTH.                         |                                      |                                                                                     |             |                                         |                                                                                       |             |
| 4) TORQUE VALUES GIVEN REPRESENT 70% TO 80% OF PROOF STRENGTH.                       |                                      |                                                                                     |             |                                         |                                                                                       |             |
| 5) CLAMP FORCE IS BASED ON 75% OF PROOF STRENGTH.                                    |                                      |                                                                                     |             |                                         |                                                                                       |             |
| 6) THESE TORQUE VALUES ARE TO BE FOLLOWED UNLESS OTHERWISE SPECIFIED.                |                                      |                                                                                     |             |                                         |                                                                                       | 2 of 7      |



| TORQUE VALUES FOR LIGHT MACHINE OIL LUBRICATED BOLTS                                                                                                                                                                                                                                                                                                                                                      |                                |                                                                                     |             |                                |                                                                                       |             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------|-------------|--------------------------------|---------------------------------------------------------------------------------------|-------------|
| JPSJ                                                                                                                                                                                                                                                                                                                                                                                                      | GRADE 8                        |                                                                                     |             | HOLO-KROME                     |                                                                                       |             |
| 31-Mar-92                                                                                                                                                                                                                                                                                                                                                                                                 | TENSILE STRENGTH = 150,000 PSI |                                                                                     |             | TENSILE STRENGTH = 170,000 PSI |                                                                                       |             |
|                                                                                                                                                                                                                                                                                                                                                                                                           | PROOF STRENGTH = 120,000 PSI   |                                                                                     |             | PROOF STRENGTH = 136,000 PSI   |                                                                                       |             |
|                                                                                                                                                                                                                                                                                                                                                                                                           |                                |                                                                                     |             |                                |                                                                                       |             |
|                                                                                                                                                                                                                                                                                                                                                                                                           |                                |                                                                                     |             |                                |                                                                                       |             |
|                                                                                                                                                                                                                                                                                                                                                                                                           |                                |                                                                                     |             |                                |                                                                                       |             |
| COARSE THREAD SERIES - UNC                                                                                                                                                                                                                                                                                                                                                                                |                                |                                                                                     |             |                                |                                                                                       |             |
| Dia-Threads                                                                                                                                                                                                                                                                                                                                                                                               | MIN. TORQUE                    | MAX. TORQUE                                                                         | CLAMP FORCE | MIN. TORQUE                    | MAX. TORQUE                                                                           | CLAMP FORCE |
| Per Inch                                                                                                                                                                                                                                                                                                                                                                                                  | (ft-lbf)                       | (ft-lbf)                                                                            | (lb)        | (ft-lbf)                       | (ft-lbf)                                                                              | (lb)        |
| 1/4 - 20                                                                                                                                                                                                                                                                                                                                                                                                  | 11.4                           | 12.6                                                                                | 2,860       | 12                             | 14                                                                                    | 3,240       |
| 5/16 - 18                                                                                                                                                                                                                                                                                                                                                                                                 | 24                             | 26                                                                                  | 3,720       | 26                             | 28                                                                                    | 5,340       |
| 3/8 - 16                                                                                                                                                                                                                                                                                                                                                                                                  | 43                             | 47                                                                                  | 7,000       | 47                             | 51                                                                                    | 7,920       |
| 7/16 - 14                                                                                                                                                                                                                                                                                                                                                                                                 | 67                             | 74                                                                                  | 9,550       | 75                             | 83                                                                                    | 10,850      |
| 1/2 - 13                                                                                                                                                                                                                                                                                                                                                                                                  | 105                            | 116                                                                                 | 12,750      | 114                            | 126                                                                                   | 14,450      |
| 9/16 - 12                                                                                                                                                                                                                                                                                                                                                                                                 | 143                            | 158                                                                                 | 16,100      | 163                            | 181                                                                                   | 18,500      |
| 5/8 - 11                                                                                                                                                                                                                                                                                                                                                                                                  | 209                            | 231                                                                                 | 20,350      | 226                            | 250                                                                                   | 23,000      |
| 3/4 - 10                                                                                                                                                                                                                                                                                                                                                                                                  | 361                            | 399                                                                                 | 30,100      | 404                            | 446                                                                                   | 34,000      |
| 7/8 - 9                                                                                                                                                                                                                                                                                                                                                                                                   | 570                            | 630                                                                                 | 41,600      | 651                            | 719                                                                                   | 47,000      |
| 1 - 8                                                                                                                                                                                                                                                                                                                                                                                                     | 855                            | 945                                                                                 | 54,500      | 969                            | 1,071                                                                                 | 61,700      |
| 1 1/8 - 7                                                                                                                                                                                                                                                                                                                                                                                                 | 1216                           | 1344                                                                                | 68,700      | 1,349                          | 1,491                                                                                 | 77,800      |
| 1 1/4 - 7                                                                                                                                                                                                                                                                                                                                                                                                 | 1729                           | 1911                                                                                | 87,200      | 1,967                          | 2,174                                                                                 | 98,700      |
| 1 3/8 - 6                                                                                                                                                                                                                                                                                                                                                                                                 | 2261                           | 2499                                                                                | 104,000     | 2,565                          | 2,835                                                                                 | 117,800     |
| 1 1/2 - 6                                                                                                                                                                                                                                                                                                                                                                                                 | 3002                           | 3318                                                                                | 126,500     | 3,411                          | 3,770                                                                                 | 143,200     |
| FINE THREAD SERIES - UNF                                                                                                                                                                                                                                                                                                                                                                                  |                                |                                                                                     |             |                                |                                                                                       |             |
| 1/4 - 28                                                                                                                                                                                                                                                                                                                                                                                                  | 13.3                           | 14.7                                                                                | 3,280       | 14                             | 16                                                                                    | 3,750       |
| 5/16 - 24                                                                                                                                                                                                                                                                                                                                                                                                 | 24                             | 26                                                                                  | 5,220       | 29                             | 32                                                                                    | 5,920       |
| 3/8 - 24                                                                                                                                                                                                                                                                                                                                                                                                  | 48                             | 53                                                                                  | 7,900       | 52                             | 58                                                                                    | 8,050       |
| 7/16 - 20                                                                                                                                                                                                                                                                                                                                                                                                 | 76                             | 84                                                                                  | 10,700      | 84                             | 92                                                                                    | 12,150      |
| 1/2 - 20                                                                                                                                                                                                                                                                                                                                                                                                  | 114                            | 126                                                                                 | 14,400      | 124                            | 137                                                                                   | 16,250      |
| 9/16 - 18                                                                                                                                                                                                                                                                                                                                                                                                 | 162                            | 179                                                                                 | 18,250      | 183                            | 203                                                                                   | 20,700      |
| 5/8 - 18                                                                                                                                                                                                                                                                                                                                                                                                  | 228                            | 252                                                                                 | 23,000      | 258                            | 286                                                                                   | 26,200      |
| 3/4 - 16                                                                                                                                                                                                                                                                                                                                                                                                  | 399                            | 441                                                                                 | 33,600      | 451                            | 499                                                                                   | 38,000      |
| 7/8 - 14                                                                                                                                                                                                                                                                                                                                                                                                  | 627                            | 693                                                                                 | 45,800      | 718                            | 794                                                                                   | 51,900      |
| 1 - 14                                                                                                                                                                                                                                                                                                                                                                                                    | 950                            | 1,050                                                                               | 59,700      | 1,064                          | 1,176                                                                                 | 67,600      |
| 1 1/8 - 12                                                                                                                                                                                                                                                                                                                                                                                                | 1,368                          | 1,512                                                                               | 77,000      | 1,511                          | 1,670                                                                                 | 87,000      |
| 1 1/4 - 12                                                                                                                                                                                                                                                                                                                                                                                                | 1,900                          | 2,100                                                                               | 96,600      | 2,180                          | 2,410                                                                                 | 109,400     |
| 1 3/8 - 12                                                                                                                                                                                                                                                                                                                                                                                                | 2,584                          | 2,856                                                                               | 118,400     | 2,926                          | 3,234                                                                                 | 134,000     |
| 1 1/2 - 12                                                                                                                                                                                                                                                                                                                                                                                                | 3,382                          | 3,738                                                                               | 142,200     | 4,769                          | 5,271                                                                                 | 201,000     |
| BOLT I.D.                                                                                                                                                                                                                                                                                                                                                                                                 |                                |  |             |                                |  |             |
| 1) VALUES ARE BASED ON LIGHT MACHINE OIL LUBRICATED BOLTS (NOT HIGH-PRESSURE LUBES).<br>2) VARCO DOES NOT RECCOMEND ASSEMBLING BOLTS DRY.<br>3) PROOF STRENGTH IS APPROX 92% OF MINIMUM 'YIELD' STRENGTH.<br>4) TORQUE VALUES GIVEN REPRESENT 70% TO 80% OF PROOF STRENGTH.<br>5) CLAMP FORCE IS BASED ON 75% OF PROOF STRENGTH.<br>6) THESE TORQUE VALUES ARE TO BE FOLLOWED UNLESS OTHERWISE SPECIFIED. |                                |                                                                                     |             |                                |                                                                                       |             |
|                                                                                                                                                                                                                                                                                                                                                                                                           |                                |                                                                                     |             |                                |                                                                                       | 3 of 7      |

| TORQUE VALUES FOR LIGHT MACHINE OIL LUBRICATED BOLTS                                 |                                        |                                                                                     |             |                                |                                                                                       |             |
|--------------------------------------------------------------------------------------|----------------------------------------|-------------------------------------------------------------------------------------|-------------|--------------------------------|---------------------------------------------------------------------------------------|-------------|
| JPSJ                                                                                 | STAINLESS ASTM F593G & F593H           |                                                                                     |             | STAINLESS ASTM F593U           |                                                                                       |             |
| 31-Mar-92                                                                            | T.S. = 100,000 PSI TO 5/8" DIA         |                                                                                     |             | TENSILE STRENGTH = 135,000 PSI |                                                                                       |             |
|                                                                                      | PROOF STRENGTH = 59,000 PSI            |                                                                                     |             | PROOF STRENGTH = 95,000 PSI    |                                                                                       |             |
|                                                                                      | T.S. = 85,000 PSI (3/4" TO 1-1/2" DIA) |                                                                                     |             |                                |                                                                                       |             |
|                                                                                      | PROOF STRENGTH = 41,000 PSI            |                                                                                     |             |                                |                                                                                       |             |
|                                                                                      |                                        |                                                                                     |             |                                |                                                                                       |             |
| COARSE THREAD SERIES - UNC                                                           |                                        |                                                                                     |             |                                |                                                                                       |             |
| Dia-Threads                                                                          | MIN. TORQUE                            | MAX. TORQUE                                                                         | CLAMP FORCE | MIN. TORQUE                    | MAX. TORQUE                                                                           | CLAMP FORCE |
| Per Inch                                                                             | (ft-lbf)                               | (ft-lbf)                                                                            | (lb)        | (ft-lbf)                       | (ft-lbf)                                                                              | (lb)        |
| 1/4 - 20                                                                             | 5.7                                    | 6.3                                                                                 | 1,407       | 8.6                            | 9.5                                                                                   | 2,266       |
| 5/16 - 18                                                                            | 11.4                                   | 12.6                                                                                | 2,319       | 18.1                           | 20.0                                                                                  | 3,734       |
| 3/8 - 16                                                                             | 20.0                                   | 22.1                                                                                | 3,429       | 33.3                           | 36.8                                                                                  | 5,522       |
| 7/16 - 14                                                                            | 32                                     | 36                                                                                  | 4,704       | 52                             | 58                                                                                    | 7,574       |
| 1/2 - 13                                                                             | 49                                     | 55                                                                                  | 6,279       | 80                             | 88                                                                                    | 10,110      |
| 9/16 - 12                                                                            | 72                                     | 80                                                                                  | 8,054       | 116                            | 128                                                                                   | 12,968      |
| 5/8 - 11                                                                             | 99                                     | 109                                                                                 | 10,001      | 160                            | 176                                                                                   | 16,103      |
| 3/4 - 10                                                                             | 122                                    | 134                                                                                 | 10,271      | 282                            | 312                                                                                   | 23,798      |
| 7/8 - 9                                                                              | 197                                    | 217                                                                                 | 14,207      | 456                            | 504                                                                                   | 32,918      |
| 1 - 8                                                                                | 295                                    | 327                                                                                 | 18,635      | 684                            | 756                                                                                   | 43,179      |
| 1 1/8 - 7                                                                            | 418                                    | 462                                                                                 | 23,462      | 968                            | 1070                                                                                  | 54,364      |
| 1 1/4 - 7                                                                            | 590                                    | 652                                                                                 | 29,797      | 1366                           | 1510                                                                                  | 69,041      |
| 1 3/8 - 6                                                                            | 773                                    | 855                                                                                 | 35,516      | 1792                           | 1980                                                                                  | 82,294      |
| 1 1/2 - 6                                                                            | 1026                                   | 1134                                                                                | 43,204      | 2378                           | 2628                                                                                  | 100,106     |
|                                                                                      |                                        |                                                                                     |             |                                |                                                                                       |             |
| FINE THREAD SERIES - UNF                                                             |                                        |                                                                                     |             |                                |                                                                                       |             |
| 1/4 - 28                                                                             | 6.7                                    | 7.4                                                                                 | 1,611       | 10.5                           | 11.6                                                                                  | 2,594       |
| 5/16 - 24                                                                            | 12.4                                   | 13.7                                                                                | 2,567       | 20.9                           | 23.1                                                                                  | 4,133       |
| 3/8 - 24                                                                             | 22.8                                   | 25.2                                                                                | 3,885       | 37                             | 41                                                                                    | 6,256       |
| 7/16 - 20                                                                            | 36                                     | 40                                                                                  | 5,252       | 59                             | 65                                                                                    | 8,457       |
| 1/2 - 20                                                                             | 56                                     | 62                                                                                  | 7,076       | 90                             | 100                                                                                   | 11,393      |
| 9/16 - 18                                                                            | 80                                     | 88                                                                                  | 8,983       | 129                            | 143                                                                                   | 14,464      |
| 5/8 - 18                                                                             | 112                                    | 124                                                                                 | 11,328      | 181                            | 200                                                                                   | 18,240      |
| 3/4 - 16                                                                             | 136                                    | 150                                                                                 | 11,470      | 315                            | 349                                                                                   | 26,576      |
| 7/8 - 14                                                                             | 217                                    | 239                                                                                 | 15,652      | 503                            | 555                                                                                   | 36,266      |
| 1 - 14                                                                               | 323                                    | 357                                                                                 | 20,387      | 748                            | 826                                                                                   | 47,239      |
| 1 1/8 - 12                                                                           | 469                                    | 519                                                                                 | 26,322      | 1087                           | 1201                                                                                  | 60,990      |
| 1 1/4 - 12                                                                           | 653                                    | 721                                                                                 | 32,995      | 1513                           | 1673                                                                                  | 76,451      |
| 1 3/8 - 12                                                                           | 881                                    | 973                                                                                 | 40,436      | 2040                           | 2254                                                                                  | 93,694      |
| 1 1/2 - 12                                                                           | 1154                                   | 1276                                                                                | 48,616      | 2675                           | 2957                                                                                  | 112,646     |
| BOLT I.D.                                                                            |                                        |  |             |                                |  |             |
| 1) VALUES ARE BASED ON LIGHT MACHINE OIL LUBRICATED BOLTS (NOT HIGH-PRESSURE LUBES). |                                        |                                                                                     |             |                                |                                                                                       |             |
| 2) VARCO DOES NOT RECCOMMEND ASSEMBLING BOLTS DRY.                                   |                                        |                                                                                     |             |                                |                                                                                       |             |
| 3) PROOF STRENGTH IS APPROX 92% OF MINIMUM 'YIELD' STRENGTH.                         |                                        |                                                                                     |             |                                |                                                                                       |             |
| 4) TORQUE VALUES GIVEN REPRESENT 70% TO 80% OF PROOF STRENGTH.                       |                                        |                                                                                     |             |                                |                                                                                       |             |
| 5) CLAMP FORCE IS BASED ON 75% OF PROOF STRENGTH.                                    |                                        |                                                                                     |             |                                |                                                                                       |             |
| 6) THESE TORQUE VALUES ARE TO BE FOLLOWED UNLESS OTHERWISE SPECIFIED.                |                                        |                                                                                     |             |                                |                                                                                       |             |
|                                                                                      |                                        |                                                                                     |             |                                |                                                                                       | 4 of 7      |

| TORQUE VALUES FOR BOLTS LUBRICATED WITH AN ANTI-SEIZE COMPOUND                    |                                                                                     |             |             |                                                                                       |             |             |
|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------|-------------|---------------------------------------------------------------------------------------|-------------|-------------|
| JPSJ                                                                              | GRADE 2                                                                             |             |             | GRADE 5                                                                               |             |             |
| 31-Mar-92                                                                         | T.S. = 74,000 PSI TO 3/4" DIA                                                       |             |             | T.S. = 120,000 PSI TO 1" DIA                                                          |             |             |
|                                                                                   | PROOF STRENGTH = 55,000 PSI                                                         |             |             | PROOF STRENGTH = 85,000 PSI                                                           |             |             |
|                                                                                   | T.S. = 60,000 PSI 7/8" to 1-1/2" DIA                                                |             |             | T.S. = 105,000 PSI 1-1/8" to 1-1/2" DIA                                               |             |             |
|                                                                                   | PROOF STRENGTH = 33,000 PSI                                                         |             |             | PROOF STRENGTH = 74,000 PSI                                                           |             |             |
| COARSE THREAD SERIES - UNC                                                        |                                                                                     |             |             |                                                                                       |             |             |
| Dia-Threads                                                                       | MIN. TORQUE                                                                         | MAX. TORQUE | CLAMP FORCE | MIN. TORQUE                                                                           | MAX. TORQUE | CLAMP FORCE |
| Per Inch                                                                          | (ft-lbf)                                                                            | (ft-lbf)    | (lb)        | (ft-lbf)                                                                              | (ft-lbf)    | (lb)        |
| 1/4 - 20                                                                          | 4.3                                                                                 | 4.7         | 1,320       | 5.7                                                                                   | 6.3         | 2,020       |
| 5/16 - 18                                                                         | 7.8                                                                                 | 8.7         | 2,160       | 12.1                                                                                  | 13.4        | 3,340       |
| 3/8 - 16                                                                          | 14.3                                                                                | 15.8        | 3,200       | 21.4                                                                                  | 23.6        | 4,940       |
| 7/16 - 14                                                                         | 21.4                                                                                | 23.6        | 4,380       | 36                                                                                    | 39          | 6,800       |
| 1/2 - 13                                                                          | 36                                                                                  | 39          | 5,840       | 53                                                                                    | 59          | 9,050       |
| 9/16 - 12                                                                         | 50                                                                                  | 55          | 7,500       | 78                                                                                    | 87          | 11,600      |
| 5/8 - 11                                                                          | 71                                                                                  | 79          | 9,300       | 107                                                                                   | 118         | 14,400      |
| 3/4 - 10                                                                          | 125                                                                                 | 138         | 13,800      | 185                                                                                   | 205         | 21,300      |
| 7/8 - 9                                                                           | 118                                                                                 | 130         | 11,400      | 306                                                                                   | 339         | 29,400      |
| 1 - 8                                                                             | 178                                                                                 | 197         | 15,000      | 456                                                                                   | 504         | 38,600      |
| 1 1/8 - 7                                                                         | 249                                                                                 | 276         | 18,900      | 570                                                                                   | 630         | 42,300      |
| 1 1/4 - 7                                                                         | 356                                                                                 | 394         | 24,000      | 798                                                                                   | 882         | 53,800      |
| 1 3/8 - 6                                                                         | 470                                                                                 | 520         | 28,600      | 1,040                                                                                 | 1,150       | 64,100      |
| 1 1/2 - 6                                                                         | 620                                                                                 | 685         | 34,800      | 1,382                                                                                 | 1,528       | 78,000      |
| FINE THREAD SERIES - UNF                                                          |                                                                                     |             |             |                                                                                       |             |             |
| 1/4 - 28                                                                          | 4.3                                                                                 | 4.7         | 1,500       | 7.1                                                                                   | 7.9         | 2,320       |
| 5/16 - 24                                                                         | 8.6                                                                                 | 9.5         | 2,400       | 13.5                                                                                  | 15.0        | 3,700       |
| 3/8 - 24                                                                          | 16.4                                                                                | 18.1        | 3,620       | 25                                                                                    | 28          | 5,600       |
| 7/16 - 20                                                                         | 25                                                                                  | 28          | 4,900       | 39                                                                                    | 43          | 7,550       |
| 1/2 - 20                                                                          | 39                                                                                  | 43          | 6,600       | 64                                                                                    | 71          | 10,700      |
| 9/16 - 18                                                                         | 57                                                                                  | 63          | 8,400       | 86                                                                                    | 95          | 12,950      |
| 5/8 - 18                                                                          | 78                                                                                  | 87          | 10,600      | 121                                                                                   | 134         | 16,300      |
| 3/4 - 16                                                                          | 139                                                                                 | 154         | 15,400      | 214                                                                                   | 236         | 23,800      |
| 7/8 - 14                                                                          | 132                                                                                 | 146         | 12,600      | 335                                                                                   | 370         | 32,400      |
| 1 - 14                                                                            | 192                                                                                 | 213         | 16,400      | 499                                                                                   | 551         | 42,200      |
| 1 1/8 - 12                                                                        | 285                                                                                 | 315         | 21,200      | 627                                                                                   | 693         | 47,500      |
| 1 1/4 - 12                                                                        | 392                                                                                 | 433         | 26,600      | 884                                                                                   | 977         | 59,600      |
| 1 3/8 - 12                                                                        | 527                                                                                 | 583         | 32,500      | 1,197                                                                                 | 1,323       | 73,000      |
| 1 1/2 - 12                                                                        | 698                                                                                 | 772         | 39,100      | 1,568                                                                                 | 1,733       | 87,700      |
| BOLT I.D.                                                                         |  |             |             |  |             |             |
| 1) TORQUE VALUES ARE BASED ON ALL THREADS LUBRICATED WITH AN ANTI-SEIZE COMPOUND. |                                                                                     |             |             |                                                                                       |             |             |
| 2) VARCO RECOMMENDS APPLYING AN ANTI-SIEZE COMPOUND TO ALL BOLTS.                 |                                                                                     |             |             |                                                                                       |             |             |
| 3) PROOF STRENGTH IS APPROX 92% OF MINIMUM 'YIELD' STRENGTH.                      |                                                                                     |             |             |                                                                                       |             |             |
| 4) TORQUE VALUES GIVEN REPRESENT 70% TO 80% OF PROOF STRENGTH.                    |                                                                                     |             |             |                                                                                       |             |             |
| 5) CLAMP FORCE IS BASED ON 75% OF PROOF STRENGTH.                                 |                                                                                     |             |             |                                                                                       |             |             |
| 6) THESE TORQUE VALUES ARE TO BE FOLLOWED UNLESS OTHERWISE SPECIFIED.             |                                                                                     |             |             |                                                                                       |             |             |
| 5 of 7                                                                            |                                                                                     |             |             |                                                                                       |             |             |

| TORQUE VALUES FOR BOLTS LUBRICATED WITH AN ANTI-SEIZE COMPOUND                    |                                |                                                                                     |             |                                |                                                                                       |             |
|-----------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------------------------------------|-------------|--------------------------------|---------------------------------------------------------------------------------------|-------------|
| JPSJ                                                                              | GRADE 8                        |                                                                                     |             | HOLO-KROME                     |                                                                                       |             |
| 31-Mar-92                                                                         | TENSILE STRENGTH = 150,000 PSI |                                                                                     |             | TENSILE STRENGTH = 170,000 PSI |                                                                                       |             |
|                                                                                   | PROOF STRENGTH = 120,000 PSI   |                                                                                     |             | PROOF STRENGTH = 136,000 PSI   |                                                                                       |             |
|                                                                                   |                                |                                                                                     |             |                                |                                                                                       |             |
|                                                                                   |                                |                                                                                     |             |                                |                                                                                       |             |
|                                                                                   |                                |                                                                                     |             |                                |                                                                                       |             |
| COARSE THREAD SERIES - UNC                                                        |                                |                                                                                     |             |                                |                                                                                       |             |
| Dia-Threads                                                                       | MIN. TORQUE                    | MAX. TORQUE                                                                         | CLAMP FORCE | MIN. TORQUE                    | MAX. TORQUE                                                                           | CLAMP FORCE |
| Per Inch                                                                          | (ft-lbf)                       | (ft-lbf)                                                                            | (lb)        | (ft-lbf)                       | (ft-lbf)                                                                              | (lb)        |
| 1/4 - 20                                                                          | 8.6                            | 9.5                                                                                 | 2,860       | 9.3                            | 10.2                                                                                  | 3,240       |
| 5/16 - 18                                                                         | 17.8                           | 19.7                                                                                | 3,720       | 19                             | 21                                                                                    | 5,340       |
| 3/8 - 16                                                                          | 32                             | 35                                                                                  | 7,000       | 35                             | 39                                                                                    | 7,920       |
| 7/16 - 14                                                                         | 50                             | 55                                                                                  | 9,550       | 56                             | 62                                                                                    | 10,850      |
| 1/2 - 13                                                                          | 78                             | 87                                                                                  | 12,750      | 86                             | 95                                                                                    | 14,450      |
| 9/16 - 12                                                                         | 107                            | 118                                                                                 | 16,100      | 123                            | 135                                                                                   | 18,500      |
| 5/8 - 11                                                                          | 157                            | 173                                                                                 | 20,350      | 170                            | 187                                                                                   | 23,000      |
| 3/4 - 10                                                                          | 271                            | 299                                                                                 | 30,100      | 303                            | 335                                                                                   | 34,000      |
| 7/8 - 9                                                                           | 428                            | 473                                                                                 | 41,600      | 488                            | 539                                                                                   | 47,000      |
| 1 - 8                                                                             | 641                            | 709                                                                                 | 54,500      | 727                            | 803                                                                                   | 61,700      |
| 1 1/8 - 7                                                                         | 912                            | 1,008                                                                               | 68,700      | 1,012                          | 1,118                                                                                 | 77,800      |
| 1 1/4 - 7                                                                         | 1,297                          | 1,433                                                                               | 87,200      | 1,475                          | 1,630                                                                                 | 98,700      |
| 1 3/8 - 6                                                                         | 1,696                          | 1,874                                                                               | 104,000     | 1,924                          | 2,126                                                                                 | 117,800     |
| 1 1/2 - 6                                                                         | 2,252                          | 2,489                                                                               | 126,500     | 2,558                          | 2,827                                                                                 | 143,200     |
|                                                                                   |                                |                                                                                     |             |                                |                                                                                       |             |
| FINE THREAD SERIES - UNF                                                          |                                |                                                                                     |             |                                |                                                                                       |             |
| 1/4 - 28                                                                          | 10.0                           | 11.0                                                                                | 3,280       | 10.7                           | 11.8                                                                                  | 3,750       |
| 5/16 - 24                                                                         | 17.8                           | 19.7                                                                                | 5,220       | 21                             | 24                                                                                    | 5,920       |
| 3/8 - 24                                                                          | 36                             | 39                                                                                  | 7,900       | 39                             | 43                                                                                    | 8,050       |
| 7/16 - 20                                                                         | 57                             | 63                                                                                  | 10,700      | 63                             | 69                                                                                    | 12,150      |
| 1/2 - 20                                                                          | 86                             | 95                                                                                  | 14,400      | 93                             | 102                                                                                   | 16,250      |
| 9/16 - 18                                                                         | 121                            | 134                                                                                 | 18,250      | 138                            | 152                                                                                   | 20,700      |
| 5/8 - 18                                                                          | 171                            | 189                                                                                 | 23,000      | 194                            | 214                                                                                   | 26,200      |
| 3/4 - 16                                                                          | 299                            | 331                                                                                 | 33,600      | 338                            | 374                                                                                   | 38,000      |
| 7/8 - 14                                                                          | 470                            | 520                                                                                 | 45,800      | 539                            | 595                                                                                   | 51,900      |
| 1 - 14                                                                            | 713                            | 788                                                                                 | 59,700      | 798                            | 882                                                                                   | 67,600      |
| 1 1/8 - 12                                                                        | 1,026                          | 1,134                                                                               | 77,000      | 1,133                          | 1,252                                                                                 | 87,000      |
| 1 1/4 - 12                                                                        | 1,425                          | 1,575                                                                               | 96,600      | 1,635                          | 1,807                                                                                 | 109,400     |
| 1 3/8 - 12                                                                        | 1,938                          | 2,142                                                                               | 118,400     | 2,195                          | 2,426                                                                                 | 134,000     |
| 1 1/2 - 12                                                                        | 2,537                          | 2,804                                                                               | 142,200     | 3,577                          | 3,953                                                                                 | 201,000     |
|                                                                                   |                                |                                                                                     |             |                                |                                                                                       |             |
| BOLT I.D.                                                                         |                                |  |             |                                |  |             |
|                                                                                   |                                |                                                                                     |             |                                |                                                                                       |             |
| 1) TORQUE VALUES ARE BASED ON ALL THREADS LUBRICATED WITH AN ANTI-SEIZE COMPOUND. |                                |                                                                                     |             |                                |                                                                                       |             |
| 2) VARCO RECOMMENDS APPLYING AN ANTI-SIEZE COMPOUND TO ALL BOLTS.                 |                                |                                                                                     |             |                                |                                                                                       |             |
| 3) PROOF STRENGTH IS APPROX 92% OF MINIMUM 'YIELD' STRENGTH.                      |                                |                                                                                     |             |                                |                                                                                       |             |
| 4) TORQUE VALUES GIVEN REPRESENT 70% TO 80% OF PROOF STRENGTH.                    |                                |                                                                                     |             |                                |                                                                                       |             |
| 5) CLAMP FORCE IS BASED ON 75% OF PROOF STRENGTH.                                 |                                |                                                                                     |             |                                |                                                                                       |             |
| 6) THESE TORQUE VALUES ARE TO BE FOLLOWED UNLESS OTHERWISE SPECIFIED.             |                                |                                                                                     |             |                                |                                                                                       |             |

| TORQUE VALUES FOR BOLTS LUBRICATED WITH AN ANTI-SEIZE COMPOUND                    |                                        |                                                                                     |             |                                |                                                                                       |             |
|-----------------------------------------------------------------------------------|----------------------------------------|-------------------------------------------------------------------------------------|-------------|--------------------------------|---------------------------------------------------------------------------------------|-------------|
| JPSJ                                                                              | STAINLESS ASTM F593G & F593H           |                                                                                     |             | STAINLESS ASTM F593U           |                                                                                       |             |
| 31-Mar-92                                                                         | T.S. = 100,000 PSI TO 5/8" DIA         |                                                                                     |             | TENSILE STRENGTH = 135,000 PSI |                                                                                       |             |
|                                                                                   | PROOF STRENGTH = 59,000 PSI            |                                                                                     |             | PROOF STRENGTH = 95,000 PSI    |                                                                                       |             |
|                                                                                   | T.S. = 85,000 PSI (3/4" TO 1-1/2" DIA) |                                                                                     |             |                                |                                                                                       |             |
|                                                                                   | PROOF STRENGTH = 41,000 PSI            |                                                                                     |             |                                |                                                                                       |             |
|                                                                                   |                                        |                                                                                     |             |                                |                                                                                       |             |
| COARSE THREAD SERIES - UNC                                                        |                                        |                                                                                     |             |                                |                                                                                       |             |
| Dia-Threads                                                                       | MIN. TORQUE                            | MAX. TORQUE                                                                         | CLAMP FORCE | MIN. TORQUE                    | MAX. TORQUE                                                                           | CLAMP FORCE |
| Per Inch                                                                          | (ft-lbf)                               | (ft-lbf)                                                                            | (lb)        | (ft-lbf)                       | (ft-lbf)                                                                              | (lb)        |
| 1/4 - 20                                                                          | 4.3                                    | 4.7                                                                                 | 1,407       | 6.4                            | 7.1                                                                                   | 2,266       |
| 5/16 - 18                                                                         | 8.6                                    | 9.5                                                                                 | 2,319       | 13.5                           | 15.0                                                                                  | 3,734       |
| 3/8 - 16                                                                          | 15.0                                   | 16.5                                                                                | 3,429       | 24.9                           | 27.6                                                                                  | 5,522       |
| 7/16 - 14                                                                         | 24                                     | 27                                                                                  | 4,704       | 39                             | 43                                                                                    | 7,574       |
| 1/2 - 13                                                                          | 37                                     | 41                                                                                  | 6,279       | 60                             | 66                                                                                    | 10,110      |
| 9/16 - 12                                                                         | 54                                     | 60                                                                                  | 8,054       | 87                             | 96                                                                                    | 12,968      |
| 5/8 - 11                                                                          | 74                                     | 82                                                                                  | 10,001      | 120                            | 132                                                                                   | 16,103      |
| 3/4 - 10                                                                          | 91                                     | 101                                                                                 | 10,271      | 212                            | 234                                                                                   | 23,798      |
| 7/8 - 9                                                                           | 147                                    | 163                                                                                 | 14,207      | 342                            | 378                                                                                   | 32,918      |
| 1 - 8                                                                             | 222                                    | 245                                                                                 | 18,635      | 513                            | 567                                                                                   | 43,179      |
| 1 1/8 - 7                                                                         | 314                                    | 347                                                                                 | 23,462      | 726                            | 802                                                                                   | 54,364      |
| 1 1/4 - 7                                                                         | 442                                    | 489                                                                                 | 29,797      | 1025                           | 1132                                                                                  | 69,041      |
| 1 3/8 - 6                                                                         | 580                                    | 641                                                                                 | 35,516      | 1344                           | 1485                                                                                  | 82,294      |
| 1 1/2 - 6                                                                         | 770                                    | 851                                                                                 | 43,204      | 1783                           | 1971                                                                                  | 100,106     |
|                                                                                   |                                        |                                                                                     |             |                                |                                                                                       |             |
| FINE THREAD SERIES - UNE                                                          |                                        |                                                                                     |             |                                |                                                                                       |             |
| 1/4 - 28                                                                          | 5.0                                    | 5.5                                                                                 | 1,611       | 7.8                            | 8.7                                                                                   | 2,594       |
| 5/16 - 24                                                                         | 9.3                                    | 10.2                                                                                | 2,567       | 15.7                           | 17.3                                                                                  | 4,133       |
| 3/8 - 24                                                                          | 17.1                                   | 18.9                                                                                | 3,885       | 28                             | 31                                                                                    | 6,256       |
| 7/16 - 20                                                                         | 27                                     | 30                                                                                  | 5,252       | 44                             | 49                                                                                    | 8,457       |
| 1/2 - 20                                                                          | 42                                     | 46                                                                                  | 7,076       | 68                             | 75                                                                                    | 11,393      |
| 9/16 - 18                                                                         | 60                                     | 66                                                                                  | 8,983       | 97                             | 107                                                                                   | 14,464      |
| 5/8 - 18                                                                          | 84                                     | 93                                                                                  | 11,328      | 135                            | 150                                                                                   | 18,240      |
| 3/4 - 16                                                                          | 102                                    | 113                                                                                 | 11,470      | 237                            | 261                                                                                   | 26,576      |
| 7/8 - 14                                                                          | 162                                    | 180                                                                                 | 15,652      | 377                            | 417                                                                                   | 36,266      |
| 1 - 14                                                                            | 242                                    | 268                                                                                 | 20,387      | 561                            | 620                                                                                   | 47,239      |
| 1 1/8 - 12                                                                        | 352                                    | 389                                                                                 | 26,322      | 815                            | 901                                                                                   | 60,990      |
| 1 1/4 - 12                                                                        | 489                                    | 541                                                                                 | 32,995      | 1135                           | 1254                                                                                  | 76,451      |
| 1 3/8 - 12                                                                        | 660                                    | 730                                                                                 | 40,436      | 1530                           | 1691                                                                                  | 93,694      |
| 1 1/2 - 12                                                                        | 866                                    | 957                                                                                 | 48,616      | 2006                           | 2218                                                                                  | 112,646     |
|                                                                                   |                                        |                                                                                     |             |                                |                                                                                       |             |
| BOLT I.D.                                                                         |                                        |  |             |                                |  |             |
|                                                                                   |                                        |                                                                                     |             |                                |                                                                                       |             |
| 1) TORQUE VALUES ARE BASED ON ALL THREADS LUBRICATED WITH AN ANTI-SEIZE COMPOUND. |                                        |                                                                                     |             |                                |                                                                                       |             |
| 2) VARCO RECOMMENDS APPLYING AN ANTI-SIEZE COMPOUND TO ALL BOLTS.                 |                                        |                                                                                     |             |                                |                                                                                       |             |
| 3) PROOF STRENGTH IS APPROX 92% OF MINIMUM 'YIELD' STRENGTH.                      |                                        |                                                                                     |             |                                |                                                                                       |             |
| 4) TORQUE VALUES GIVEN REPRESENT 70% TO 80% OF PROOF STRENGTH.                    |                                        |                                                                                     |             |                                |                                                                                       |             |
| 5) CLAMP FORCE IS BASED ON 75% OF PROOF STRENGTH.                                 |                                        |                                                                                     |             |                                |                                                                                       |             |
| 6) THESE TORQUE VALUES ARE TO BE FOLLOWED UNLESS OTHERWISE SPECIFIED.             |                                        |                                                                                     |             |                                |                                                                                       |             |

---

**TDS-9S**

**Top Drive  
Drilling  
System**

**Maintenance  
and  
Troubleshooting**

---

March 9, 1998

# Contents

## Preface/Manual conventions

|                              |     |
|------------------------------|-----|
| Safety information .....     | 4-7 |
| Directional references ..... | 4-8 |
| Manual layout .....          | 4-8 |

## Chapter 1 Introduction

|                   |     |
|-------------------|-----|
| Precautions ..... | 4-9 |
|-------------------|-----|

## Chapter 2 Maintenance schedules

|                                |      |
|--------------------------------|------|
| Inspection schedules .....     | 4-11 |
| Lubrication schedules .....    | 4-13 |
| Lubricant specifications ..... | 4-14 |
| Selecting a gear oil .....     | 4-14 |
| Selecting a lubricant .....    | 4-15 |

## Chapter 3 Inspection

|                                                        |      |
|--------------------------------------------------------|------|
| Inspecting hardware and fittings .....                 | 4-17 |
| Inspecting the AC drilling motor brakes .....          | 4-17 |
| Inspecting the AC drilling motor louvers .....         | 4-19 |
| Inspecting the S-pipe .....                            | 4-20 |
| Inspecting the wash pipe assembly .....                | 4-20 |
| Inspecting the upper stem liner .....                  | 4-21 |
| Inspecting main shaft end play .....                   | 4-22 |
| Inspecting gear backlash .....                         | 4-23 |
| Inspecting the gearbox oil level .....                 | 4-24 |
| Inspecting the lubrication oil flow .....              | 4-25 |
| Inspecting the gearbox lubrication pump assembly ..... | 4-26 |
| Inspecting the guide beam .....                        | 4-28 |
| Inspecting the IBOPs .....                             | 4-28 |
| Inspecting the pipehandler .....                       | 4-28 |
| Nondestructive Examination (NDE) .....                 | 4-29 |
| Inspecting the elevator link eyes .....                | 4-30 |
| Inspecting the drive stem .....                        | 4-31 |
| Magnetic Particle Inspection (MPI) .....               | 4-32 |
| Ultrasonic inspection .....                            | 4-33 |



|                                        |      |
|----------------------------------------|------|
| Inspecting the hydraulic system .....  | 4-34 |
| Inspecting the electrical system ..... | 4-36 |

## Chapter 4 Lubrication

|                                                                         |      |
|-------------------------------------------------------------------------|------|
| Introduction .....                                                      | 4-37 |
| Lubricating the AC blower motor bearings .....                          | 4-38 |
| Lubricating the hydraulic pump AC motor .....                           | 4-39 |
| Lubricating the AC drilling motor bearings .....                        | 4-40 |
| Lubricating the wash pipe assembly .....                                | 4-42 |
| Lubricating the upper main body oil seals .....                         | 4-43 |
| Replacing the gearbox oil .....                                         | 4-44 |
| Initial oil change .....                                                | 4-44 |
| Oil capacity .....                                                      | 4-45 |
| Replacing the gearbox oil filter .....                                  | 4-46 |
| Lubricating the bail pins .....                                         | 4-46 |
| Lubricating the lower main body oil seals .....                         | 4-46 |
| Lubricating the roller carriage assembly .....                          | 4-47 |
| Lubricating the rotating link adapter .....                             | 4-48 |
| Lubricating the link tilt and PH-50<br>stabilizer bushing .....         | 4-49 |
| Lubricating the elevator support and<br>master bushing wear guide ..... | 4-50 |
| Lubricating the wireline adapter .....                                  | 4-51 |
| Lubricating the IBOP actuator yoke .....                                | 4-52 |
| Lubricating the IBOP actuator crank .....                               | 4-53 |
| Lubricating the torque arrestor tubes and<br>clamp cylinder gate .....  | 4-54 |

## Chapter 5 Maintenance

|                                             |      |
|---------------------------------------------|------|
| General hydraulic system maintenance .....  | 4-55 |
| Changing the hydraulic filter and oil ..... | 4-56 |
| Start-up procedure .....                    | 4-58 |
| Accumulator maintenance .....               | 4-58 |

## Chapter 6 Troubleshooting

|                                                                          |      |
|--------------------------------------------------------------------------|------|
| Troubleshooting the AC drilling motors .....                             | 4-59 |
| Troubleshooting the AC blower motors .....                               | 4-60 |
| Troubleshooting the hydraulic system .....                               | 4-61 |
| Troubleshooting the AC drilling<br>motor brakes .....                    | 4-66 |
| Troubleshooting the rotating link adapter<br>(rotating head) motor ..... | 4-68 |
| Operation .....                                                          | 4-68 |
| System test .....                                                        | 4-68 |
| Troubleshooting the IBOP actuator cylinder .....                         | 4-71 |
| Operation .....                                                          | 4-71 |
| System test .....                                                        | 4-72 |
| Troubleshooting the shot pin cylinder<br>and clamp cylinder .....        | 4-74 |
| Operation .....                                                          | 4-74 |
| System test .....                                                        | 4-74 |
| Troubleshooting the link tilt cylinders .....                            | 4-78 |
| Operation .....                                                          | 4-78 |
| System test .....                                                        | 4-78 |
| Troubleshooting the counterbalance system .....                          | 4-82 |
| Counterbalance testing .....                                             | 4-82 |
| Stand jump testing .....                                                 | 4-84 |
| Troubleshooting the hydraulic power unit and reservoir .....             | 4-86 |
| Operation .....                                                          | 4-86 |
| System test .....                                                        | 4-86 |
| Troubleshooting the gearbox lubrication<br>hydraulic system .....        | 4-89 |
| Operation .....                                                          | 4-89 |
| System test .....                                                        | 4-89 |

## Chapter 7 Disassembly and assembly

|                                                                      |       |
|----------------------------------------------------------------------|-------|
| Precautions .....                                                    | 4-93  |
| PH-50 Pipehandler .....                                              | 4-94  |
| Disassembling the PH-50 Pipehandler .....                            | 4-94  |
| Assembling the PH-50 Pipehandler .....                               | 4-97  |
| Rotating link adapter/load stem .....                                | 4-99  |
| Disassembling the rotating link adapter/load stem ...                | 4-99  |
| Assembling the rotating link adapter/load stem .....                 | 4-101 |
| Transmission/motor housing .....                                     | 4-105 |
| Removing the transmission/motor housing .....                        | 4-105 |
| Installing the transmission/motor housing .....                      | 4-105 |
| Disassembling the transmission/motor housing .....                   | 4-106 |
| Removing the bonnet and wash pipe .....                              | 4-106 |
| Removing the upper bearing retainer plate .....                      | 4-108 |
| Removing the AC drilling motors<br>and hydraulic oil reservoir ..... | 4-110 |
| Removing transmission components .....                               | 4-110 |
| Assembling the transmission/motor housing .....                      | 4-114 |
| Assembling the main body .....                                       | 4-114 |
| Assembling the main shaft .....                                      | 4-118 |
| Assembling the gears to the main body .....                          | 4-120 |
| Assembling the cover .....                                           | 4-122 |
| Assembling the cover to the main body .....                          | 4-122 |
| Installing the AC drilling motors .....                              | 4-124 |
| Installing the upper bearing retainer plate .....                    | 4-126 |
| Installing the bonnet and wash pipe .....                            | 4-128 |
| Checking the gear train backlash .....                               | 4-129 |
| Shot pin disassembly/assembly .....                                  | 4-130 |
| AC drilling motor disassembly/assembly .....                         | 4-132 |
| AC drilling motor disassembly .....                                  | 4-132 |
| AC drilling motor assembly .....                                     | 4-134 |
| Replacing the safety wiring .....                                    | 4-136 |
| Safety wiring tips .....                                             | 4-138 |

## Manual conventions

### Safety information

---

Information pertaining to possible personnel injury and equipment damage appears throughout this manual and is formatted to draw the reader's attention to important information, a warning, or a caution note. See the examples below and pay close attention to these important advisories.



Indicates advisories for operational or servicing procedures involving little or no risk of personnel injury and equipment damage.



*Indicates advisories involving a risk of equipment damage.*



***Indicates advisories involving a definite risk of injury to rig personnel.***

Avoid personnel injury and equipment damage by reading this manual and related documents before operating, inspecting, or servicing the equipment.

## Directional references

---

References to the right or left and front or back of components described in this manual assume the perspective of the top drive drilling system (TDS-9S), standing behind the TDS-9S as it faces well center.

## Manual layout

---

This binder contains several separate books that you can remove individually for convenience.

# Chapter 1

## Introduction

### Precautions

---

To avoid serious injury or death, read and understand the following warnings before performing maintenance procedures:



***Properly lockout the main power source before performing lubrication, inspection, or replacement procedures, unless specifically noted in this manual.***



***Wear protective glasses to prevent eye injuries from fluids under pressure, as well as other hazards.***



***Do not attempt any adjustments while the machine is moving.***



***Use caution when draining lubricant. It can be hot.***



***Never check for hydraulic leaks with your hands. Oil under pressure escaping from a hole can be nearly invisible and can penetrate skin causing serious injury. Always check for leaks with a piece of wood or cardboard and always wear protective eyewear when working on hydraulic components.***



***Always discharge the three hydro pneumatic accumulators before performing repairs on the hydraulic system.***



***Do not attempt repairs you do not understand.***



***Read and understand all safety precautions and warnings before performing maintenance procedures.***

# Chapter 2

## Maintenance schedules

### Inspection schedules

---



The service intervals listed in Table 4-1 are based on average operating conditions. Use the schedule as a guide. Some conditions (excessive loadings, dusty or corrosive atmosphere, temperature extremes, etc.) may warrant more frequent service intervals.



**Table 4-1. Inspection schedules**

| <b>Inspection</b>                                                    | <b>Frequency</b>                                                                                                                                                          |
|----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Inspect</i> gearbox oil level                                     | Daily                                                                                                                                                                     |
| <i>Inspect</i> hydraulic reservoir oil level                         | Daily                                                                                                                                                                     |
| <i>Inspect</i> for loose hardware and fittings                       | Daily                                                                                                                                                                     |
| <i>Inspect</i> wash pipe assembly for leaks                          | Daily                                                                                                                                                                     |
| <i>Inspect</i> lubrication oil spray and flow in main body           | Weekly                                                                                                                                                                    |
| <i>Inspect</i> AC drilling motor louvers                             | Weekly                                                                                                                                                                    |
| <i>Inspect</i> guide beam components                                 | Weekly                                                                                                                                                                    |
| <i>Inspect</i> upper stem liner for corrosion                        | Monthly or whenever wash pipe packing is serviced                                                                                                                         |
| <i>Inspect</i> elevator link eye diameter                            | Monthly                                                                                                                                                                   |
| <i>Inspect</i> AC drilling motor brakes for wear and hydraulic leaks | Monthly                                                                                                                                                                   |
| <i>Inspect</i> main shaft for axial movement (end play)              | 3 Months                                                                                                                                                                  |
| <i>Inspect</i> charge on accumulators (3)                            | 3 Months                                                                                                                                                                  |
| <i>Inspect</i> gears for backlash                                    | 6 Months                                                                                                                                                                  |
| <i>Inspect</i> pump adapter plate components for wear                | 12 Months                                                                                                                                                                 |
| <i>Inspect</i> S-pipe internal surfaces for wear                     | 6 Months                                                                                                                                                                  |
| <i>Inspect</i> IBOPs for damage                                      | Whenever connections are broken                                                                                                                                           |
| <i>Inspect</i> load bearing components                               | Magnetic Particle Inspection (MPI) @ 3 Months or 1,500 hours on exposed surfaces; MPI @ 5 Years over entire surface; Ultrasonic Inspection to be performed along with MPI |

# Lubrication schedules

**Table 4-2. Lubrication schedules**

| <b>Lubrication job</b>                                                                                        | <b>Frequency</b>                                                                                           |
|---------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| <i>(see Lubricant specifications for descriptions of grease and oil)</i>                                      |                                                                                                            |
| <i>Lubricate</i> wash pipe assembly (1 fitting)                                                               | Daily (general purpose grease)                                                                             |
| <i>Lubricate</i> upper main body oil seal grease fittings (2 fittings)                                        | Daily (general purpose grease)                                                                             |
| <i>Lubricate</i> IBOP actuator yoke and pins                                                                  | Daily (general purpose grease)                                                                             |
| <i>Lubricate</i> IBOP actuator cranks (2 fittings)                                                            | Daily (general purpose grease)                                                                             |
| <i>Lubricate</i> stabilizer bushing                                                                           | Daily (general purpose grease)                                                                             |
| <i>Lubricate</i> rotating link adapter grease fittings (3)                                                    | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> lower main body oil seal (1 fitting)                                                         | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> carriage assembly (24 fittings)                                                              | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> clamp cylinder gate                                                                          | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> bail pins (2 fittings)                                                                       | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> torque arrestor tubes at clamp cylinder area (2 places) and clamp cylinder gate (4 fittings) | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> link tilt                                                                                    | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> elevator support and master bushing wear guide                                               | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> the wireline adapter                                                                         | Weekly (general purpose grease)                                                                            |
| <i>Lubricate</i> AC drilling motor bearings (4 fittings)                                                      | 3 Months (motor grease)                                                                                    |
| <i>Lubricate</i> AC blower motors (4 fittings)                                                                | 3 Months (motor grease)                                                                                    |
| <i>Lubricate</i> hydraulic pump motor (2 fittings)                                                            | 3 Months (motor grease)                                                                                    |
| <i>Replace</i> gearbox oil and perform an oil analysis                                                        | 3 Months (gear oil)                                                                                        |
| <i>Replace</i> gearbox oil filter                                                                             | 3 Months                                                                                                   |
| <i>Perform</i> hydraulic system oil analysis                                                                  | 3 Months. Replace hydraulic oil every 12 months, or earlier, based on oil analysis results (hydraulic oil) |
| <i>Replace</i> hydraulic system filter                                                                        | 3 Months or sooner on indication                                                                           |

# Lubricant specifications

## Selecting a gear oil

Varco Top Drives operate under a wide variety of temperatures and conditions. The oil viscosity varies from quite thick at start-up in cold climates to very thin in hot climates during difficult drilling conditions.

Select gearbox lubrication based on the minimum ambient temperature to be expected before the next oil change. Introducing an oil viscosity greater than required by the ambient temperature could damage the gearbox due to reduced oil flow, or damage the oil pump with an excessive load.

Use the following table to select the proper gearbox lubricant.

**Table 4-3. Gearbox lubricants**

| Minimum ambient temperature |           | Oil type required | Varco P/N      |
|-----------------------------|-----------|-------------------|----------------|
| °F                          | °C        |                   |                |
| Below 20°                   | -6°       | See note below    | See note below |
| 20° to 60°                  | -6 to 16° | 2EP, ISO 68       | 56004-1        |
| 45° to 85°                  | 7° to 30° | 4EP, ISO 150      | 56004-BSC      |
| Above 70°                   | 21°       | 6EP, ISO 320      | 56004-2        |



For minimum temperatures below 20°F, warm the TDS-9S up by rotating at a very light load and very slow speeds until the oil temperature is above 20°F. Contact your local Varco service center for specific instructions.

# Selecting a lubricant

Use the following table to select the appropriate lubricant for your specific application.

**Table 4-4. Recommended lubricants**

|                           | Lube Code and Description          |                 |                      |                  |                  |
|---------------------------|------------------------------------|-----------------|----------------------|------------------|------------------|
|                           | <b>1</b><br>General Purpose Grease |                 | <b>2</b><br>Gear Oil |                  |                  |
|                           | Above -20°                         | Below -20°C     | Above 21°C           | 7° to 30°C       | -6° to 16°C      |
| Ambient temperature range |                                    |                 |                      |                  |                  |
| <b>Castrol</b>            | MP grease                          | -               | Alpha LS-320         | Alpha -150       | Alpha LS-68      |
| <b>Chevron</b>            | Avi-Motive                         | Avi-Motive W    | Alpha LS-320         | NL Gear 150      | NL Gear 68       |
| <b>Exxon</b>              | Lidok EP2                          | Lidok EP1       | Alpha LS-320         | Spartan EP150    | Spartan EP68     |
| <b>Gulf</b>               | Gulf Crown EP32                    | Gulf Crown EP31 | EP Lube HD320        | EP Lube HD150    | EP Lube HD68     |
| <b>Mobil</b>              | Mobilux EP2                        | Mobilux EP1     | MobilGear 632        | MobilGear 629    | MobilGear 626    |
| <b>Shell</b>              | Alvania EP2                        | Alvania EP1     | Omala 320            | Omala 150        | Omala 68         |
| <b>Statoil</b>            | Uniway EP2N                        | Uniway EP1N     | Loadway EP320        | Loadway EP150    | Statoil          |
| <b>Texaco</b>             | Multifak EP2                       | Multifak EP1    | Meropa 320           | Meropa 150       | Meropa 68        |
| <b>Total</b>              | Multis EP2                         | Multis EP1      | Carter EP 320        | Carter EP 150    | Carter EP 68     |
| <b>Union</b>              | Unoba EP2                          | Unoba EP1       | Extra Duty NL6EP     | Extra Duty NL4EP | Extra Duty NL2EP |
| NGL1                      | 2                                  | 1               | -                    | -                | -                |
| AGMA                      | -                                  | -               | 6EP                  | 4EP              | 2EP              |
| ISO Viscosity Grade       | -                                  | -               | 320                  | 150              | 68               |

**Table 4-4. Recommended lubricants (continued)**

|                           | Lube Code and Description |                    |                 |
|---------------------------|---------------------------|--------------------|-----------------|
|                           | 3<br>Motor Grease         | 4<br>Hydraulic Oil |                 |
| Ambient temperature range | All temperatures          | -10° to 85°C       | -15° to 75°C    |
| <b>Castrol</b>            | -                         | Hyspin AWS-46      | Hyspin AWS-32   |
| <b>Chevron</b>            | -                         | AW Hyd oil 46      | AW Hyd oil 32   |
| <b>Exxon</b>              | -                         | Nuto H46           | Nuto H32        |
| <b>Gulf</b>               | -                         | Harmony 46AW       | Harmony 32AW    |
| <b>Mobil</b>              | -                         | DTE 25             | DTE 24          |
| <b>Shell</b>              | Cyprina RA                | Tellus 46          | Tellus 32       |
| <b>Statoil</b>            | -                         | Hydraway HMA 46    | Hydraway HMA 32 |
| <b>Texaco</b>             | -                         | Rando oil HD46     | Rando oil HD32  |
| <b>Total</b>              | -                         | Azolla ZS 46       | Azolla ZS 32    |
| <b>Union</b>              | -                         | Unax AW46          | Unax AW32       |
| NGL1                      | -                         | -                  | -               |
| AGMA                      | -                         | 1                  | -               |
| ISO Viscosity Grade       | -                         | 46                 | 32              |

# Chapter 3

## Inspection

### Inspecting hardware and fittings

---

Visually inspect the TDS-9S for loose or missing hardware and fittings daily. Make sure all lockwire is undamaged.

### Inspecting the AC drilling motor brakes

---

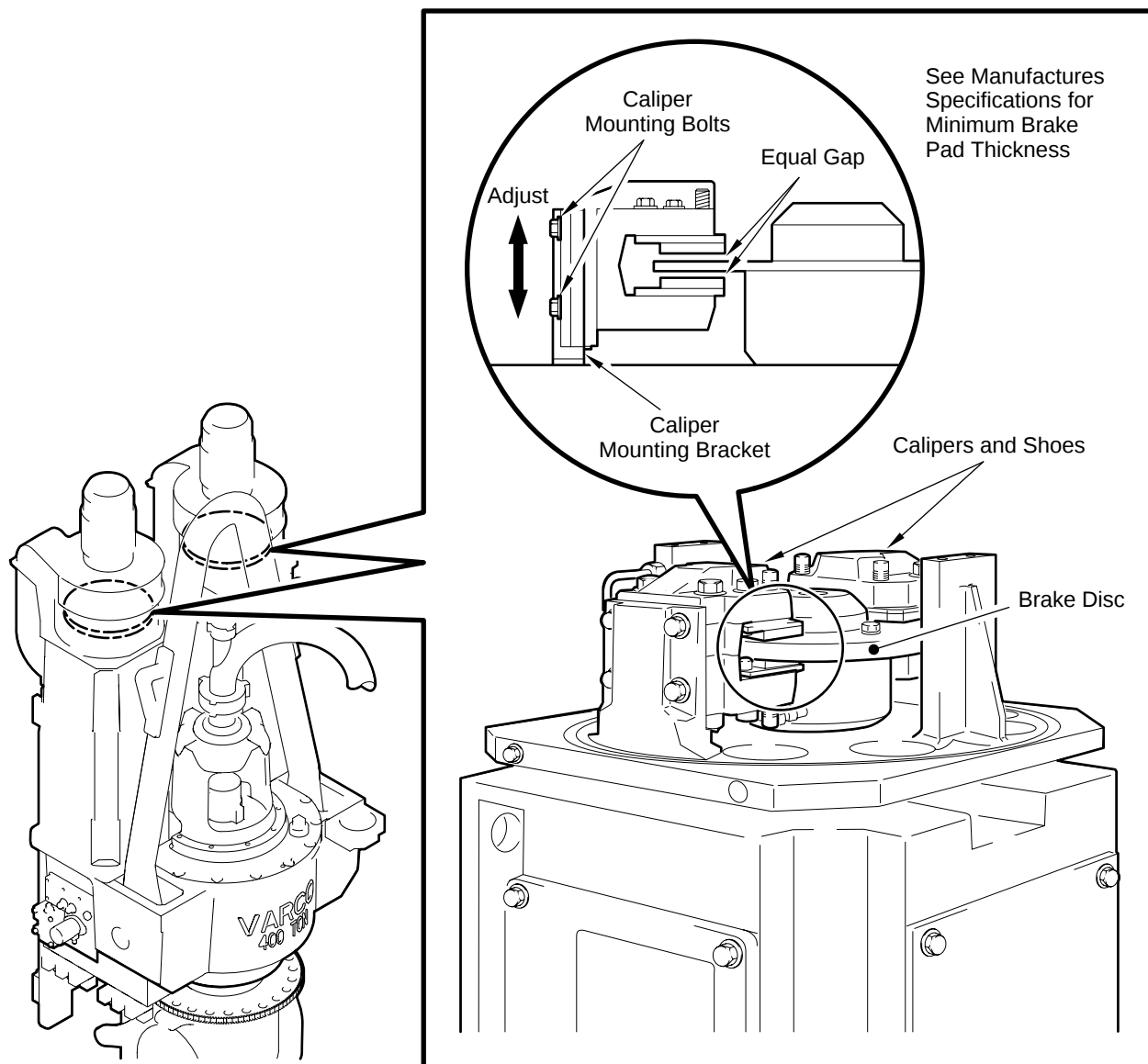
Remove the brake housing covers to access the drilling motor brakes (Figure 4-1).

Inspect the brake shoes for wear, and replace the shoes if worn below the allowable lining wear limit given by the manufacturer. If the brake shoes are wearing unevenly, adjust the brake pads by adjusting the bolts on the brake calipers.

Inspect the brake hydraulic lines for leaks.



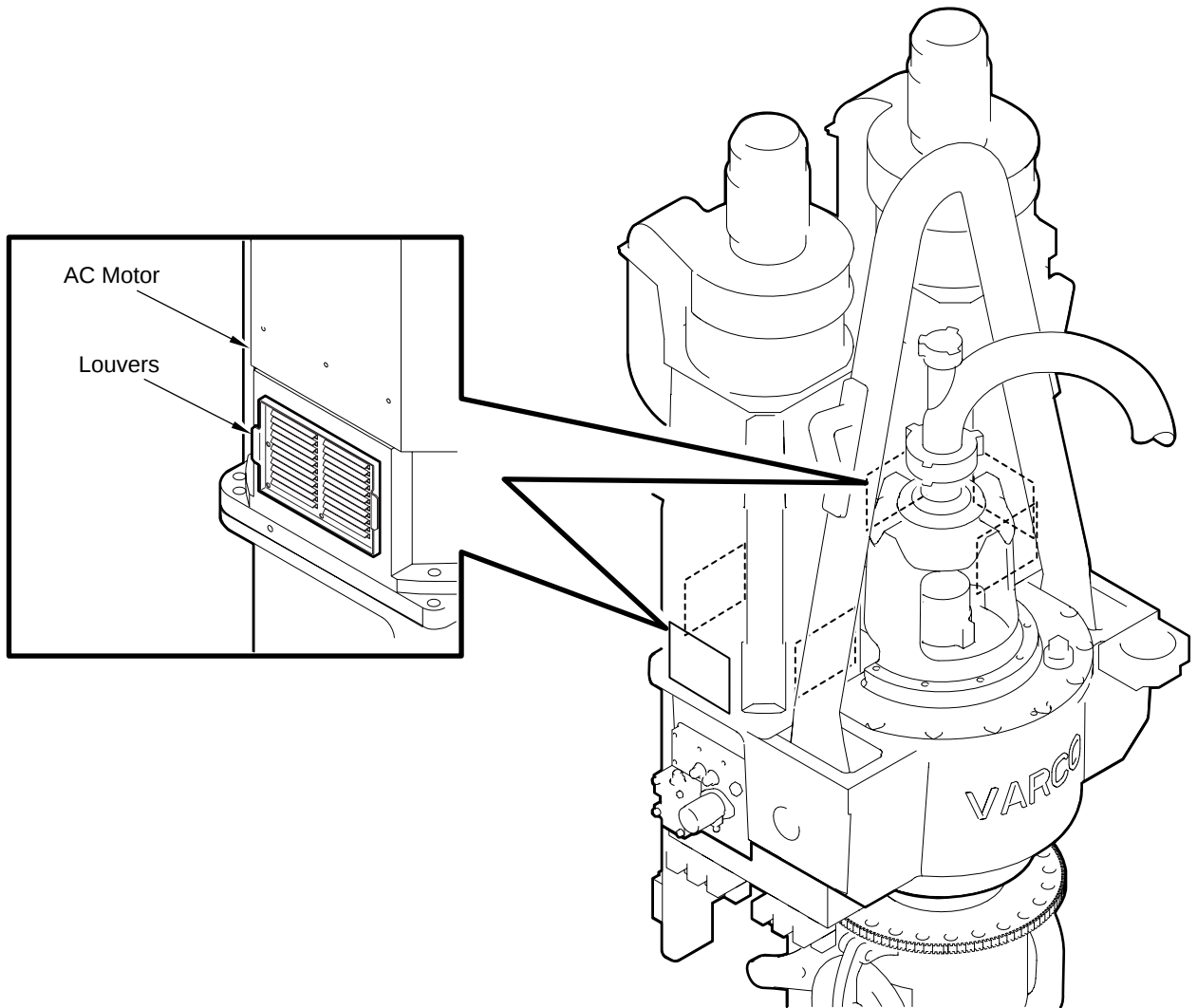
***Never check for hydraulic leaks with your hands. Oil under pressure escaping from a hole can be nearly invisible and can penetrate skin causing serious injury. Always check for leaks with a piece of wood or cardboard.***



***Figure 4-1. Inspecting the AC drilling motor brakes***

# Inspecting the AC drilling motor louvers

Check that no AC drill motor louvers are missing or damaged (Figure 4-2).



**Figure 4-2. Inspecting the AC drilling motor louvers**



## Inspecting the S-pipe

---

Unscrew the two nuts that hold the S-pipe in place along with the six bolts that secure the clamp (Figure 4-3) to remove and inspect the S-pipe.

## Inspecting the wash pipe assembly

---

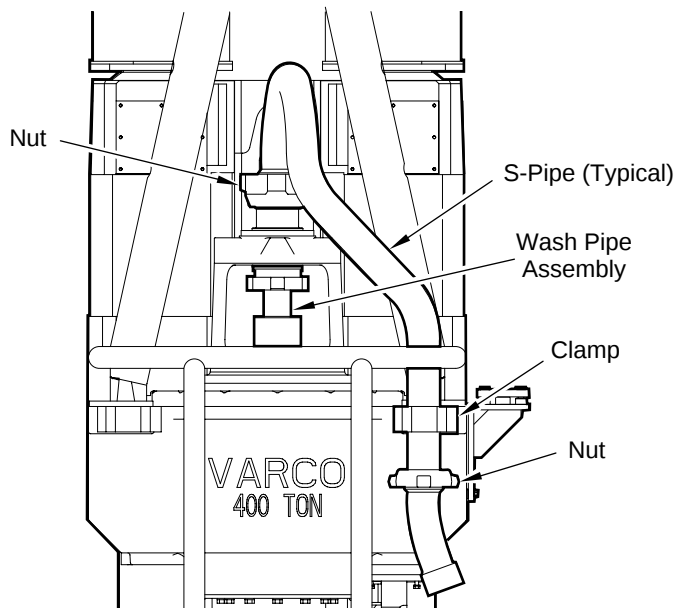
Visually inspect the wash pipe assembly daily for leaks (Figure 4-3).

Clean the bore of the S-pipe and inspect for visible signs of pitting, corrosion, or erosion.



Use a flashlight and mirror to visually inspect the bore of the S-pipe. A Bore-o-Scope is best for inspection, if available.

Remove and perform an ultrasonic inspection on the S-pipe if visual inspection indicates erosion or corrosion.



**Figure 4-3. Disconnecting the S-pipe and wash pipe assembly**

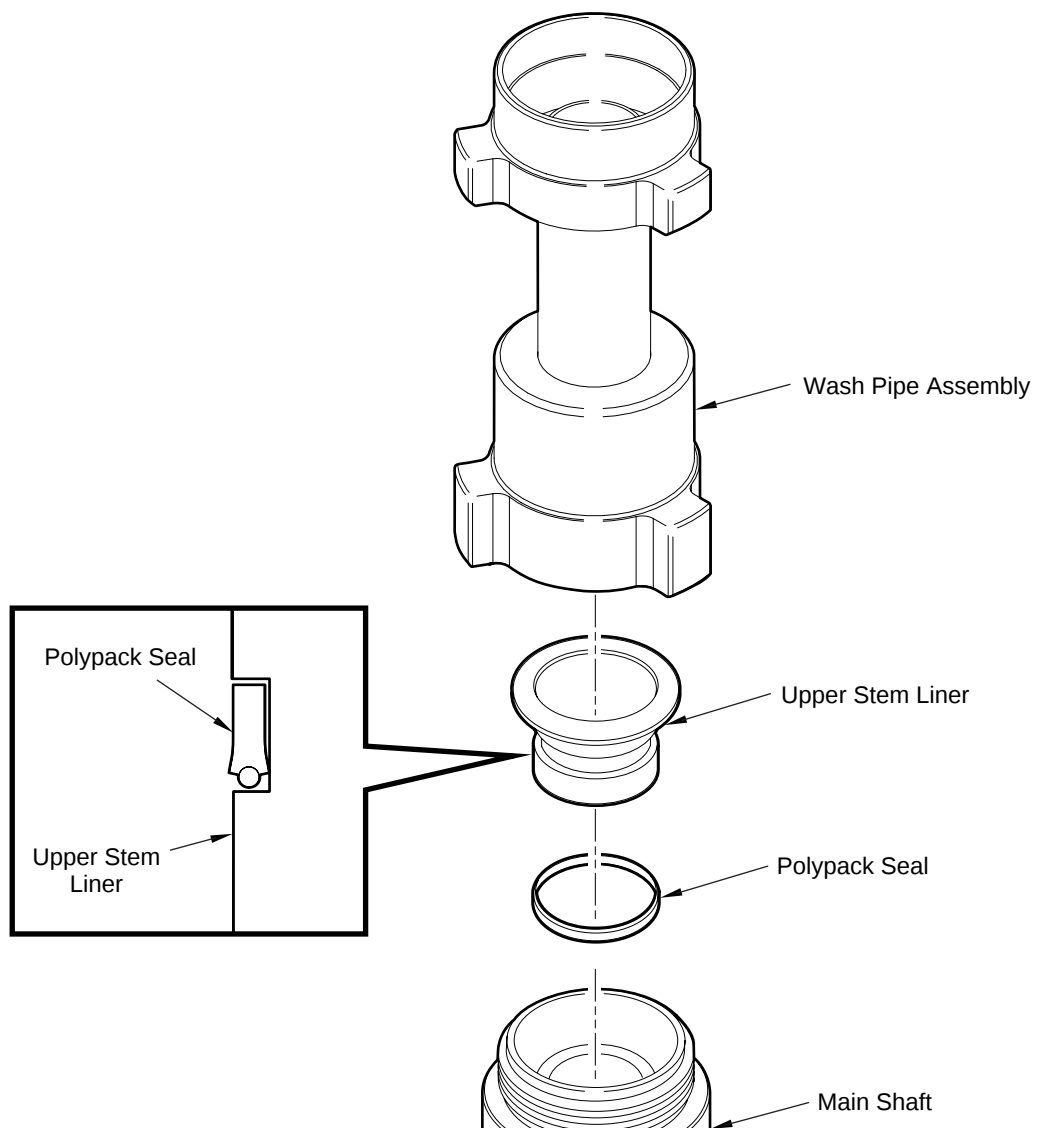
# Inspecting the upper stem liner

Use the following procedure to inspect the upper stem liner.

1. Remove the wash pipe packing (Figure 4-4).
2. Check the upper stem liner for erosion caused by leaking wash pipe packing and replace the liner if erosion is found.



The 3.875 in. OD polypack seal must also be replaced whenever the upper stem liner is replaced. Make sure the O-ring of the seal is facing down when the seal is installed on the liner.



**Figure 4-4. Inspecting the upper stem liner**

# Inspecting main shaft end play

---

Use the following procedure to check for main shaft end play:

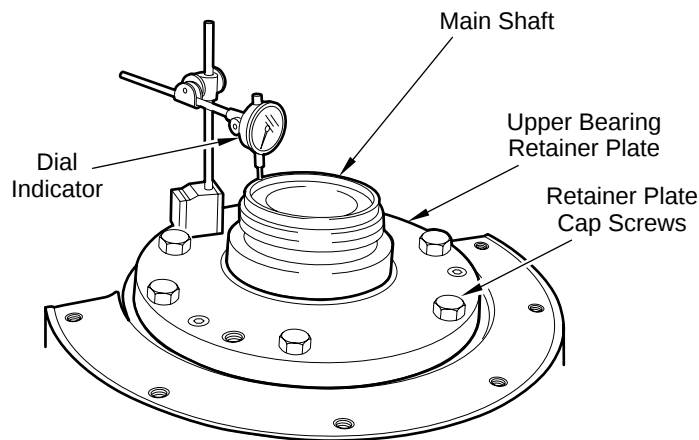
1. Remove the wash pipe packing.
2. Check the main shaft axial movement by applying an upward force to the main shaft and measuring the amount of axial movement with a dial indicator (Figure 4-5).
3. If axial shaft movement is not .001 in. to .002 in., remove the upper bearing retainer plate and adjust the number of shims under the bearing retainer plate as required to allow .001 in. to .002 in. of axial shaft movement (end play) with the retainer plate capscrews tightened to 250-270 ft lb.



Align the shims so that the upper bearing lube tube bore is not blocked.



Refer to *Installing the upper bearing retainer plate* in the *Disassembly and assembly* section of this book for further details on this adjustment.



**Figure 4-5. Inspecting the main shaft axial movement**

# Inspecting gear backlash



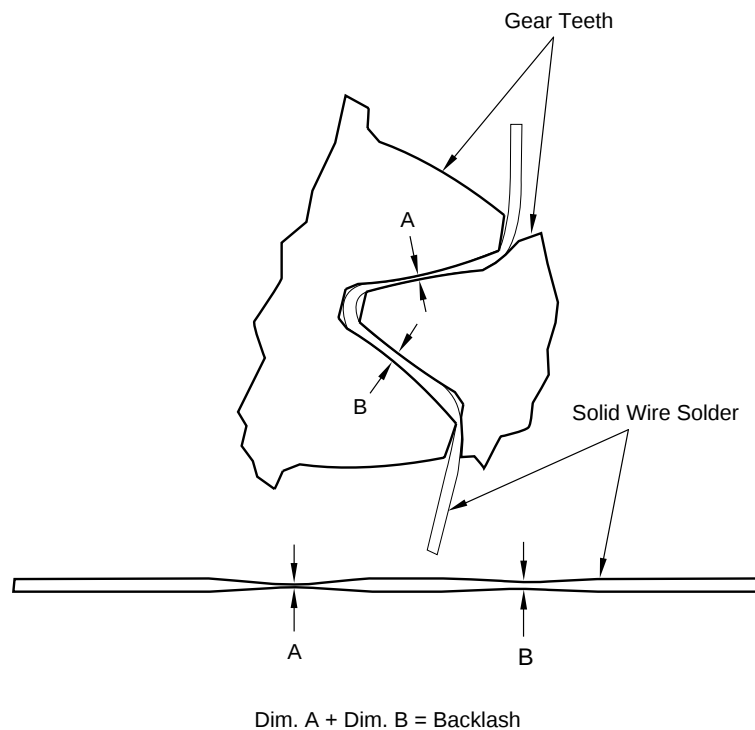
Inspect the pump adapter plate at the same time the gear backlash is checked.

Use the following procedure to check gear backlash:

1. Drain the gearbox oil.
2. Remove the access cover and the pump adapter plate to check primary and secondary gear set backlash.
3. Run a piece of solid wire solder through the primary and secondary gear meshes and measure the thickness of the two flat spots made by the gear teeth surfaces with a micrometer (Figure 4-6). If the primary gear mesh backlash exceeds .030 in. or the secondary gear mesh backlash exceeds .040 in., excessive gear wear or bearing failure is indicated.



Check the gear teeth for pitting or corrosive wear at the same time the gear set backlash is checked.



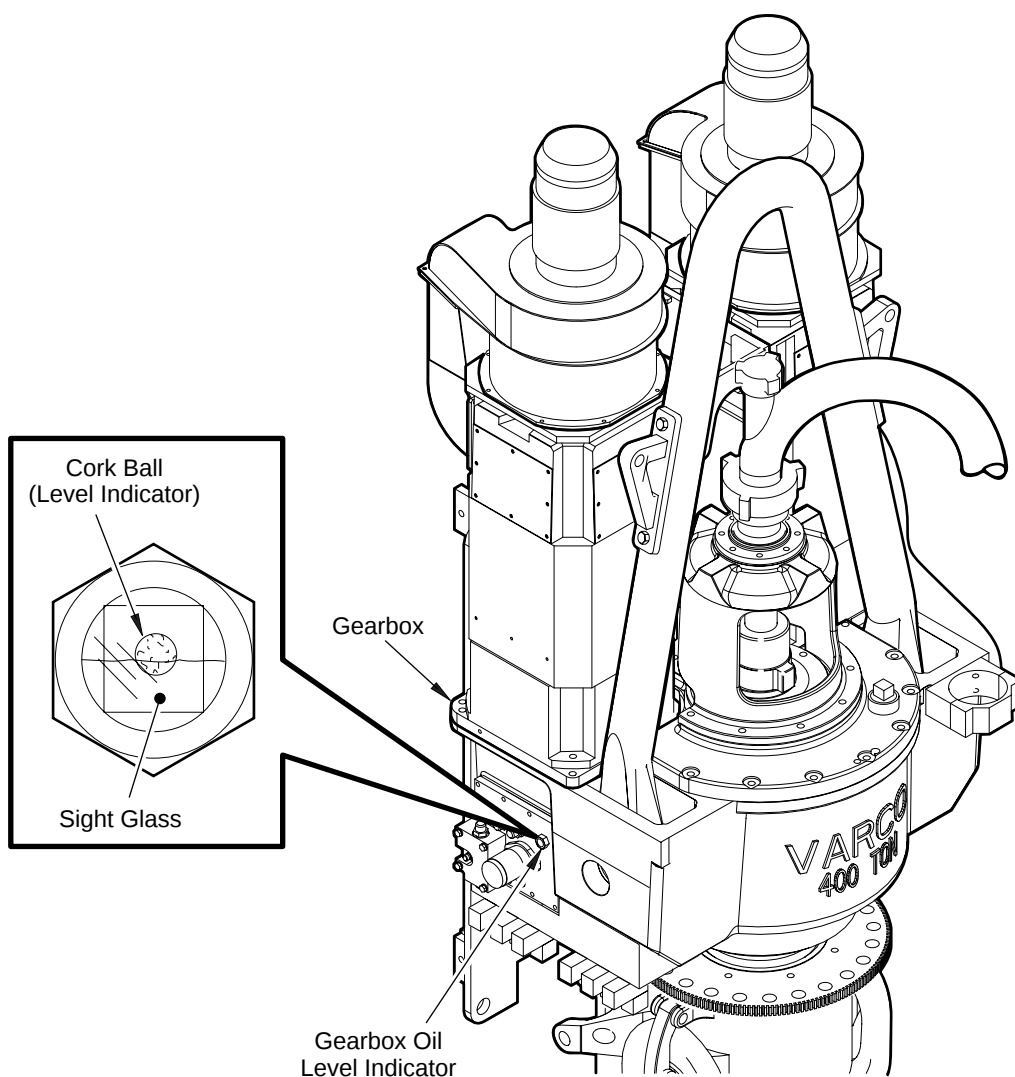
**Figure 4-6. Checking gear backlash**

# Inspecting the gearbox oil level

With the drive motors and hydraulic system off, check to see that the oil level (identified by a floating cork ball) is at the middle of the sight glass located on the lube pump adapter plate mounted on the side of the gearbox (Figure 4-7).



Always check the oil level after the unit has been running and the transmission oil is warm. Look for oil level (oil is dark brown); not foam level (foam is tan).

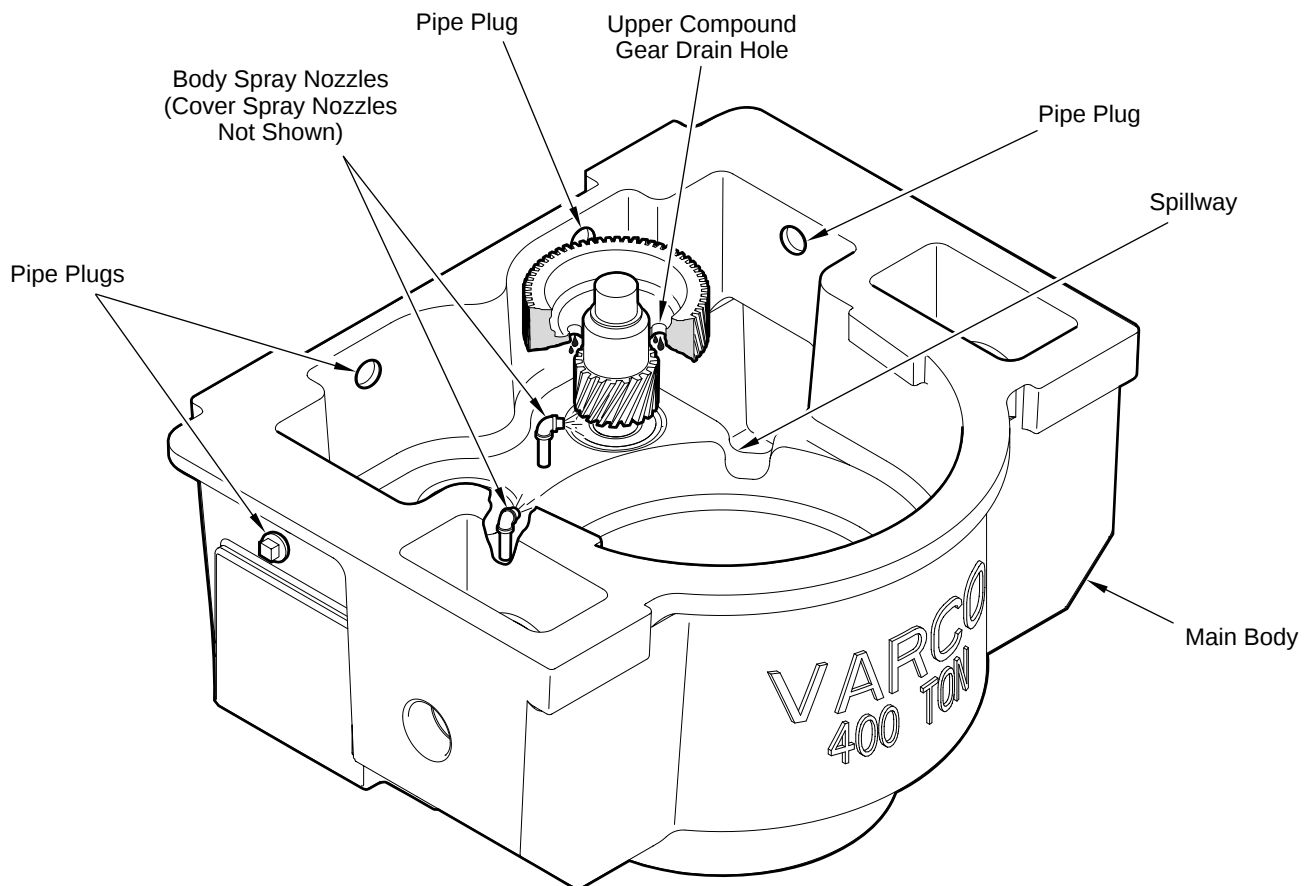


**Figure 4-7. Inspecting the gearbox oil level**

# Inspecting the lubrication oil flow

Use the following procedure to inspect the lubrication oil flow:

1. Remove the 3 in. pipe plugs from the main body and check the flow of oil coming from the four spray nozzles (two in body, two in cover) while the lube pump is operating (Figure 4-8).
2. Check that oil is running out of the upper gear drain holes in each compound gear set (indicates upper orifice is not blocked) and that oil is running through the spillway running from the thrust bearing (indicates lower orifice is not blocked).



**Figure 4-8. Checking main body oil flow**

# Inspecting the gearbox lubrication pump assembly

---

Every 12 months, disassemble the gearbox lubrication pump assembly and inspect the pump assembly components for wear and damage as follows (Figure 4-9):

1. Drain the gearbox oil and disconnect the hydraulic lines from the pump assembly.
2. Remove the pump assembly by removing the eight lockwired capscrews that attach the pump adapter plate to the main body.
3. Disassemble the spline adapter, pump, and housing using the pump vendor service instruction HS15 (located in the *Vendor Documentation Package*).
4. Inspect the pump assembly components, replacing any parts that are worn or damaged. Pay particular attention to the spline between the pump and motor, the gears, and the motor and pump sideplates.
5. Assemble the lubrication pump assembly in the reverse order of disassembly.

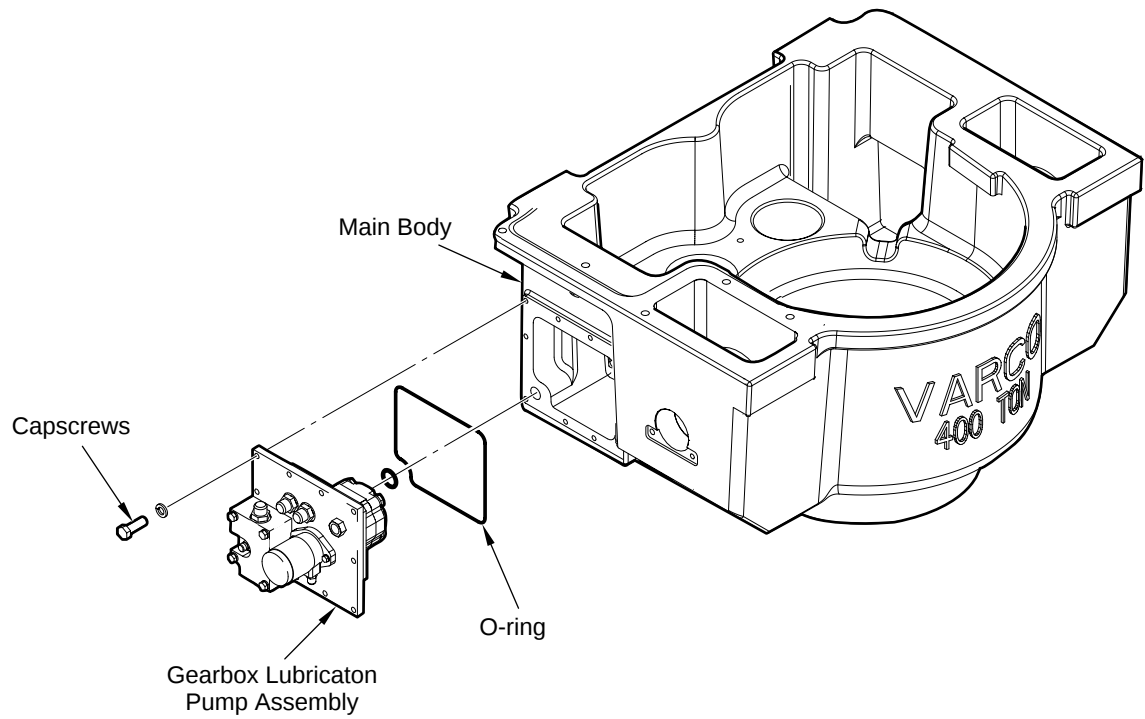


Follow the pump vendor service instruction HS15 (located in the *Vendor Documentation Package*) when assembling the lubrication pump components, and torque all fasteners in accordance with DS00008, located in the *Supplemental Materials* book.



When reinstalling the pump assembly into the main body, inspect the O-ring for damage and replace the O-ring if any flat spots, nicks, or other damage is found.

6. Install the pump assembly into the main body. Torque the fasteners in accordance with DS00008, and reconnect the hydraulic and electrical connections.



***Figure 4-9. Gearbox lubrication pump assembly***



## Inspecting the guide beam

---

Inspect the guide beam components weekly. Verify that the hinge pins and retainer pins are in place. Re-torque any loose bolts and replace any missing or damaged pins or keys.

## Inspecting the IBOPs

---



Upper and lower safety valves, because of their internal grooves and shoulders, are particularly susceptible to corrosion, fatigue, and cracking. These internal diameter changes act as stress risers for bending and tensile loads. It is especially important to properly inspect the safety valves on a frequent basis. Read and use the safety valve inspection procedures described in the *IBOP Service Manual*.

## Inspecting the pipehandler

---

Thoroughly inspect the pipehandler for loose bolts and fittings daily. If any safety wire or cotter pins were removed during repairs, replace them immediately.

Inspect the hinge pins and retainer bolts daily to make sure they are not separating from the pipehandler. Make sure the hinge pins are not loose either because of excessive wear in the bore of the gate or clamp body.



***Inspect the link tilt intermediate stop and adjustment device for overall integrity weekly. Replace or tighten the components if there is excessive looseness of the spacers and nuts. An indication of a possible problem is if the two intermediate stops are not adjusted equally (i.e., if the spacer thickness differs on the two link tilt assemblies). Failure to perform this inspection and/or component replacement can result in damage to equipment and injury to rig personnel.***

# Nondestructive Examination (NDE)

---

Yearly (or after approximately 3,000 operating hours), perform a Nondestructive Examination (NDE) of all critical load path items.



NDE inspection includes visual examination, dye penetrant examination, magnetic particle inspection, ultrasonic inspection, x-ray examination, and other methods of nondestructive testing for metallurgical integrity.

## Inspecting the elevator link eyes

Use calipers on a regular basis to measure the amount of wear on the elevator link eyes. Compare the measurements with the *Wear Chart* (Figure 4-10) to determine the current strength of the elevator links. The capacity of the links equals the capacity of the weakest link.

**Wear Chart - Forged Links**

| Upper Eye<br>Dim. C | Lower Eye<br>Dim. A | Capacity<br>(Per Set)<br>In<br>Tons |
|---------------------|---------------------|-------------------------------------|
|---------------------|---------------------|-------------------------------------|

**B = 2 7/8", 250 Ton**

|       |        |     |
|-------|--------|-----|
| 5     | 2 1/4  | 250 |
| 4 7/8 | 2 1/8  | 210 |
| 4 5/8 | 2 1/16 | 188 |
| 4 3/8 | 1 3/4  | 137 |

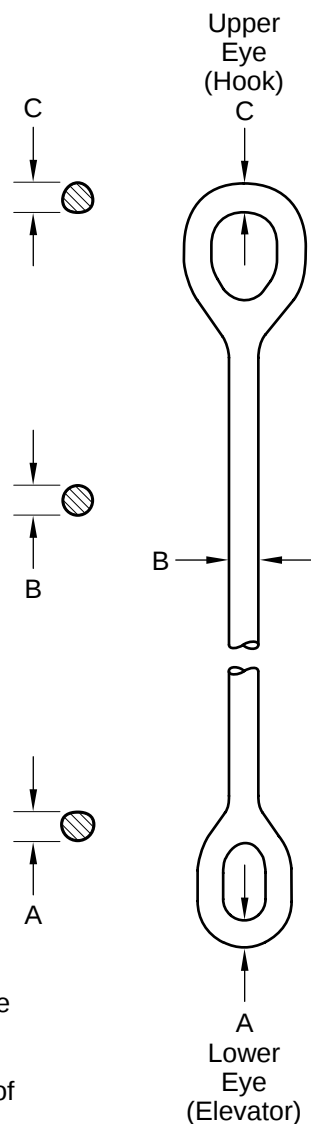
**B = 3 1/2", 350 Ton**

|         |        |     |
|---------|--------|-----|
| 5       | 2 3/4  | 350 |
| 4 13/16 | 2 9/16 | 300 |
| 4 5/8   | 2 3/8  | 225 |
| 4 7/16  | 2 3/16 | 175 |

**B = 4 1/2", 500 Ton**

|       |       |     |
|-------|-------|-----|
| 6     | 3 1/2 | 500 |
| 5 3/4 | 3 1/4 | 420 |
| 5 1/2 | 3     | 325 |
| 5 1/4 | 2 3/4 | 250 |

To Determine the strength of worn links, measure (with calipers) the amount of eye wear and compare the measurements with the above *Wear Chart* to find the current capacity. The capacity of the set of links is determined by the weakest link.



**Figure 4-10. Visual inspection of elevator links**

## Inspecting the drive stem

Regularly inspect and measure the drive stem/main shaft for wear.

Determine inspection frequency according to *API Recommended Practice 8B, Section 2* for power swivels and power subs.

Varco recommends the use of *API RP 7G* and *API RP 8B* as guidelines for interpreting and performing inspections.

Measurement techniques are specified in *API RP 7G, Section 10*. Use *API Bulletin 5T1* to identify and define imperfections found during inspections.

## Magnetic Particle Inspection (MPI)

Once a year, or every 3,000 operating hours, Varco recommends performing a Magnetic Particle Inspection (MPI) of the exposed surfaces of all load bearing components and load collar grooves to reveal any fatigue or crack indications. Any indications found are a potential cause for replacing the suspect component. Round bottom pits and erosion are acceptable as long as the defect is less than 1/16 in. deep. Larger defects or any crack indications are a cause for replacing the suspect component.

After approximately five years or 15,000 operating hours, depending on the severity of operating conditions, Varco recommends performing a MPI of all load bearing components over the entire surface (including internal bores) to reveal any fatigue or crack indications.

Any indications found are a potential cause for replacing the suspect component. Round bottom pits and erosion are acceptable as long as the defect is less than 1/16 in. deep. Larger defects or any crack indications are a cause for replacing the suspect component.

The load bearing components are:

- ☐ Bail
- ☐ Rotating link adapter
- ☐ Main body casting
- ☐ Rotating link adapter shear rings
- ☐ Main shaft
- ☐ Upper and lower IBOPs
- ☐ Load stem
- ☐ Saver sub
- ☐ Main body shear rings
- ☐ Spacer sub
- ☐ Elevator
- ☐ Power subs
- ☐ Elevator links

Details on MPI procedures are in the following publications:

- ❑ ASTM A-275, *Standard Method for Magnetic Particle Inspection of Steel Forgings*
- ❑ ASTM E-709, *Standard Recommended Practice for Magnetic Particle Inspection*
- ❑ I.A.D.C., *Drilling Manual, 9th Edition*

## Ultrasonic inspection

In addition to MPI, Varco also recommends performing an Ultrasonic Inspection of the above components to detect any erosion of the inside diameter. Any erosion reduces the load-carrying capacity of the part. Any subsurface irregularity can also compromise a component's integrity.

Details on Ultrasonic Inspection procedures are in the following publications:

- ❑ I.A.D.C., *Drilling Manual, 9th Edition*
- ❑ ASTM A-388, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

# Inspecting the hydraulic system

---



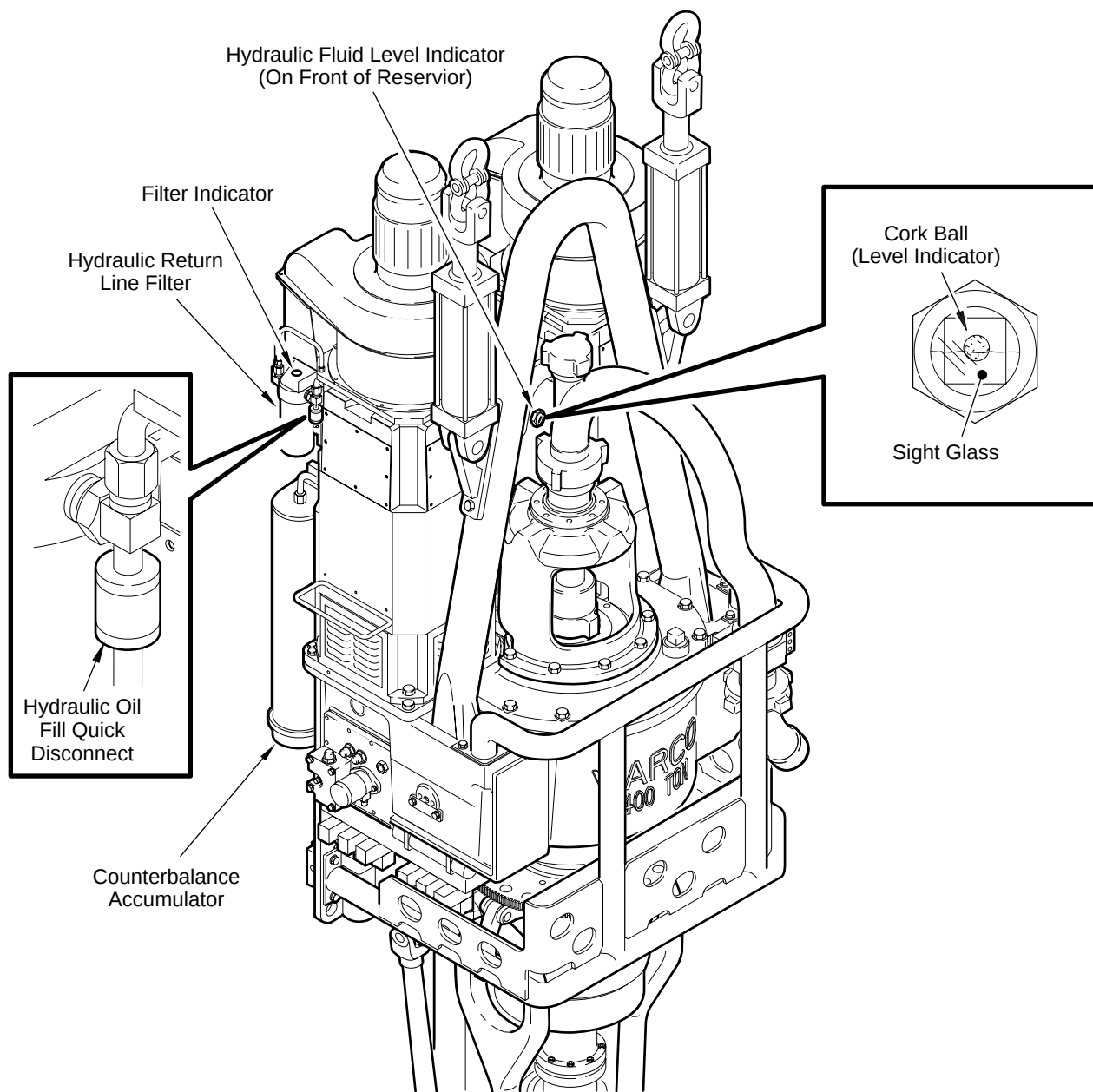
***Hydraulic fluid escaping under pressure can penetrate the skin causing serious injury. Avoid injury by discharging the three accumulators and relieving pressure before disconnecting hydraulic lines. Always search for hydraulic leaks with a piece of cardboard or wood-not with your bare hands. Get immediate medical attention for hydraulic fluid injuries. Fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Do not tighten hydraulic fittings while they are under pressure.***

Inspect the hydraulic system weekly for leaks at fittings, damaged hose covers, kinked or crushed hoses, hard or stiff hoses, and damaged or corroded fittings. In addition, during the inspection, tighten or replace any leaking port connections, and clean any dirt buildup from hydraulic components.



***Replace worn or damaged hydraulic system components immediately.***

Inspect the hydraulic fluid level in the hydraulic reservoir located between the AC drilling motors daily. Inspect the hydraulic filter located on the upper left AC drilling motor (Figure 4-11) daily.



**Figure 4-11. Hydraulic fluid reservoir and filter**



# Inspecting the electrical system

---

Periodically, depending on severity of service, check all electrical lines, connectors, and related electrical hardware for loose connections and damage, and replace components and tighten connections as necessary.

Also, inspect electrical sensors for exterior damage and replace components as required.

# Chapter 4

## Lubrication

### Introduction

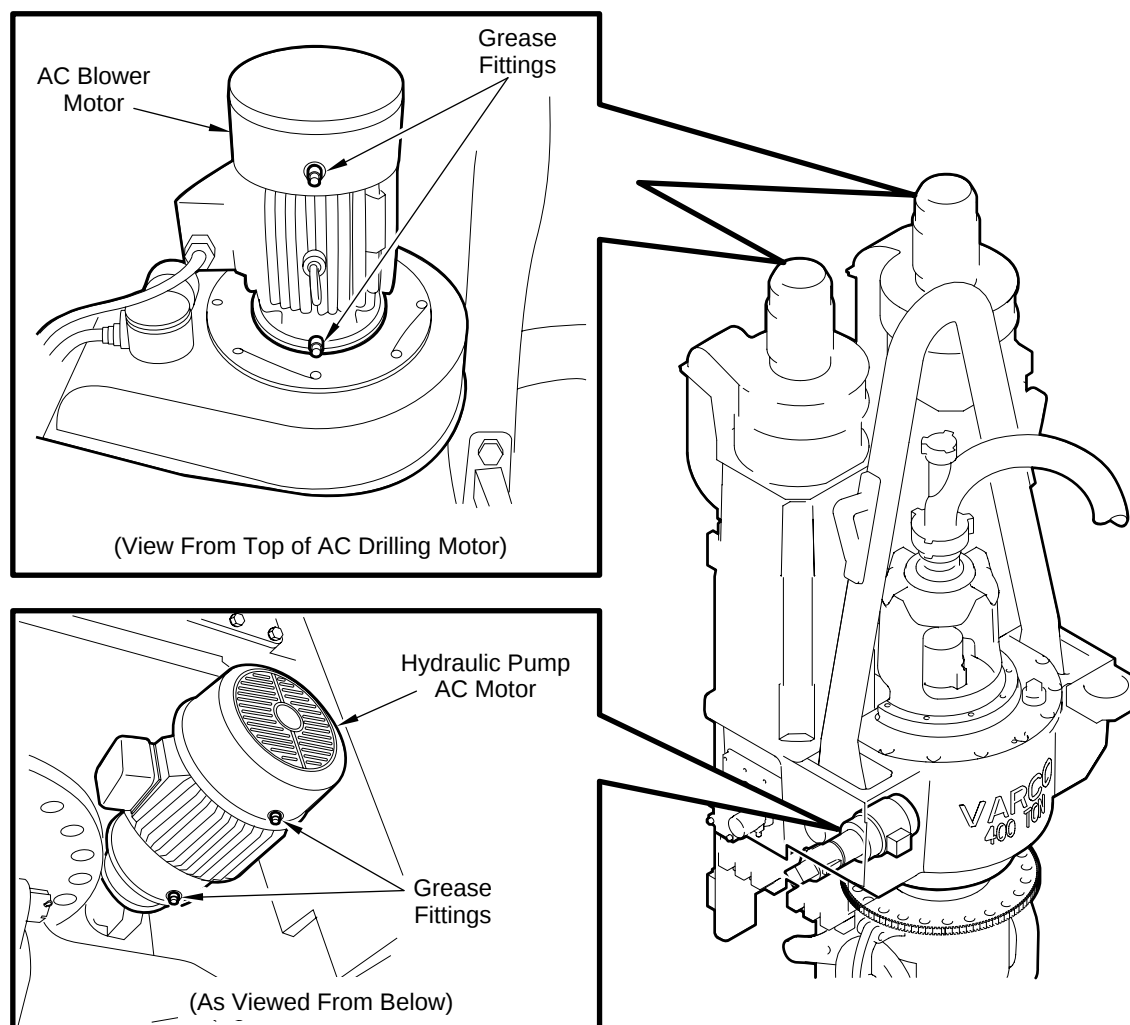
---

The lubrication intervals described in this manual are based on lubricant supplier recommendations. Severe conditions such as extreme loads or temperature, corrosive atmosphere, etc., may require more frequent lubrication.

Worn bushings, binding parts, rust accumulations, and other abnormal conditions indicate more frequent lubrication is necessary. Be careful not to over lubricate parts. For example, too much grease forced into a fitting can pop out a bearing seal. Over lubrication can also affect safety since over lubricated parts can drip, creating a potential slipping hazard for personnel.

## Lubricating the AC blower motor bearings

Remove the 1/8 in. pipe plugs and install 1/8 in. grease fittings. Apply grease every three months to the grease fittings for the bearings in the two AC blower motors. All fittings are located on the ends of the motors (Figure 4-12). After greasing, remove the fittings and reinstall the plugs.



**Figure 4-12. Lubricating the AC auxiliary motors**

# Lubricating the hydraulic pump AC motor

---

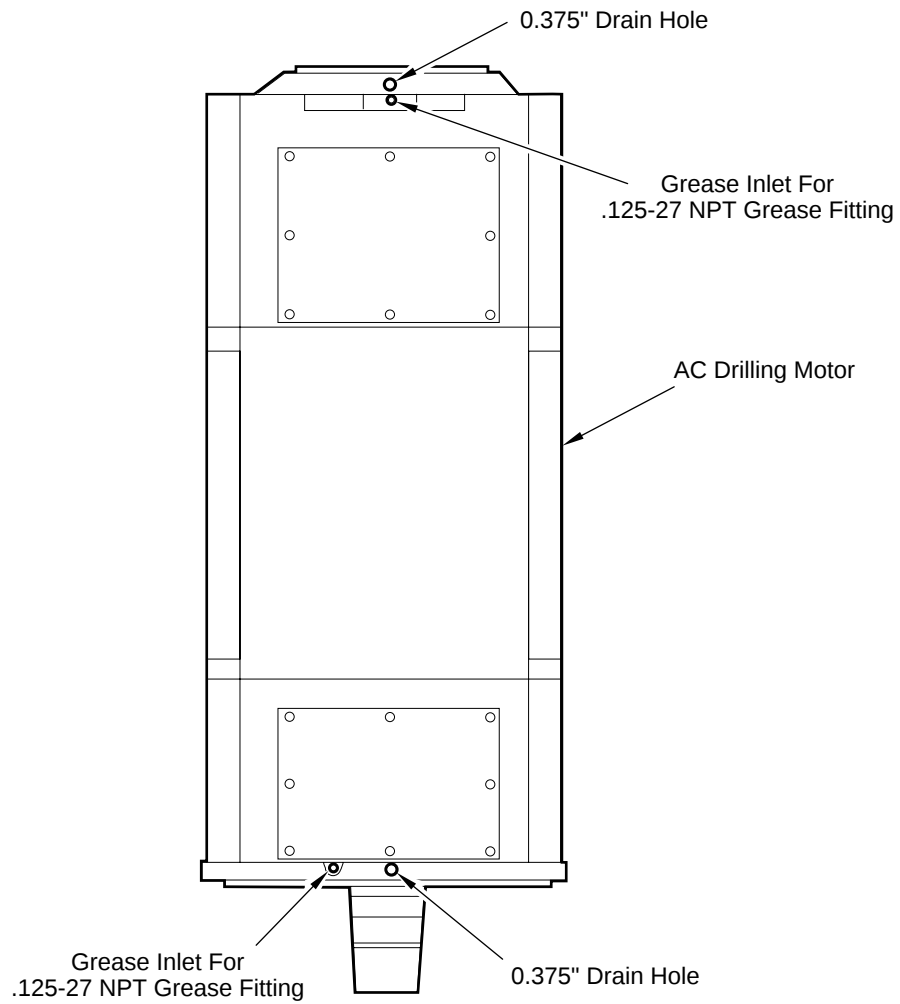
Remove the 1/8 in. pipe plugs and install 1/8 in. grease fittings. Apply grease every three months to the grease fittings for the bearings in the hydraulic pump AC motor located on top of the AC drilling motors, and to the grease fittings for the bearings in the AC motor that powers the hydraulic system. All fittings are located on the ends of the motors (Figure 4-12). After greasing, remove the fittings and reinstall the plugs.

# Lubricating the AC drilling motor bearings

---

Use the following procedure to lubricate the AC drilling motor bearings at the locations indicated every three months with the shaft stationary and the motor warm.

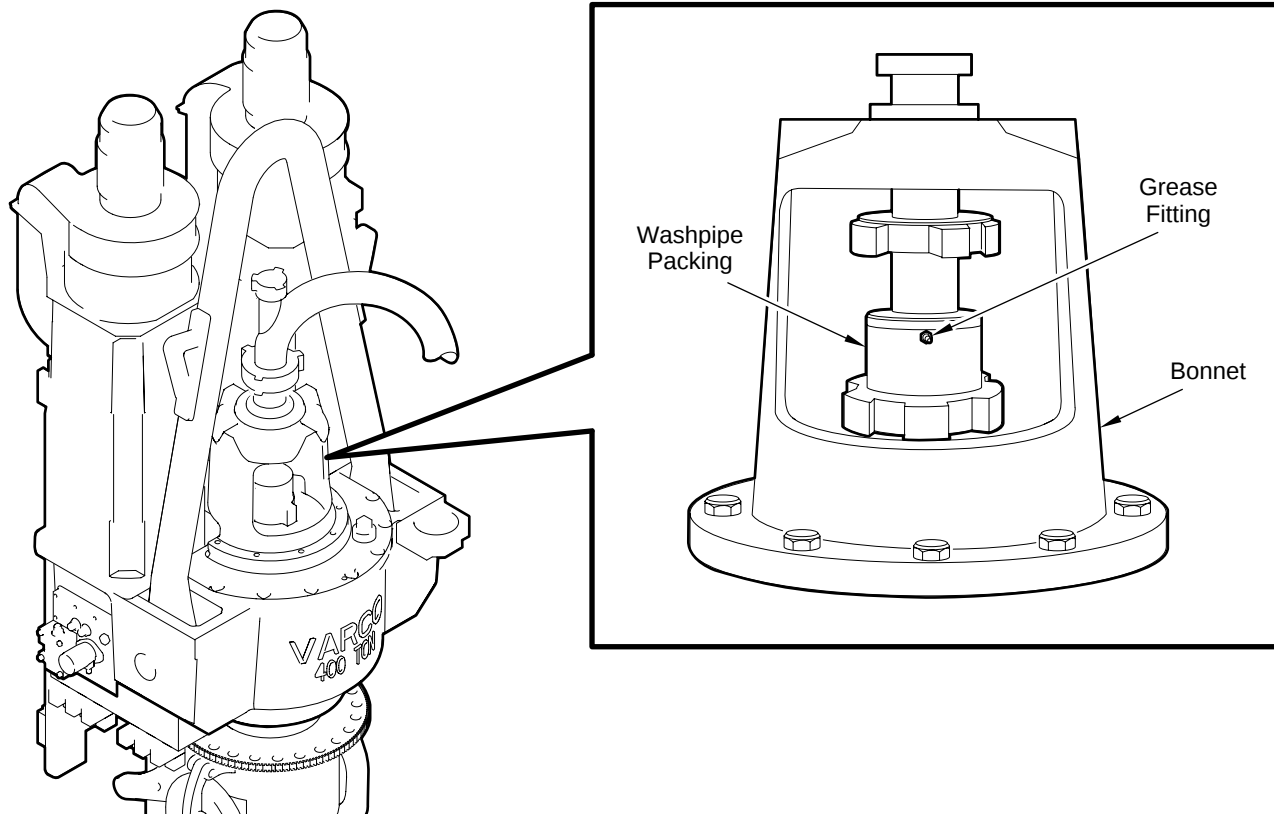
1. Locate the grease inlet at the top of the motor frame (Figure 4-13).
2. Clean the area and replace the 1/8 in. pipe plug with a grease fitting and remove the grease drain plug located opposite the grease inlet.
3. Repeat steps 1 and 2 for the bottom of the motor frame
4. Add grease to the bearing with a manual grease gun. The motor manufacturer's manual located in the *Vendor Documentation Package*, contains information on the proper amount and type of grease to use.
5. Clean any excess grease from the grease drain and replace the pipe plugs at the inlet and the drain.



**Figure 4-13. Lubricating the AC drilling motors**

# Lubricating the wash pipe assembly

Apply grease daily to the wash pipe assembly grease fitting with the mud pump shut off (Figure 4-14).



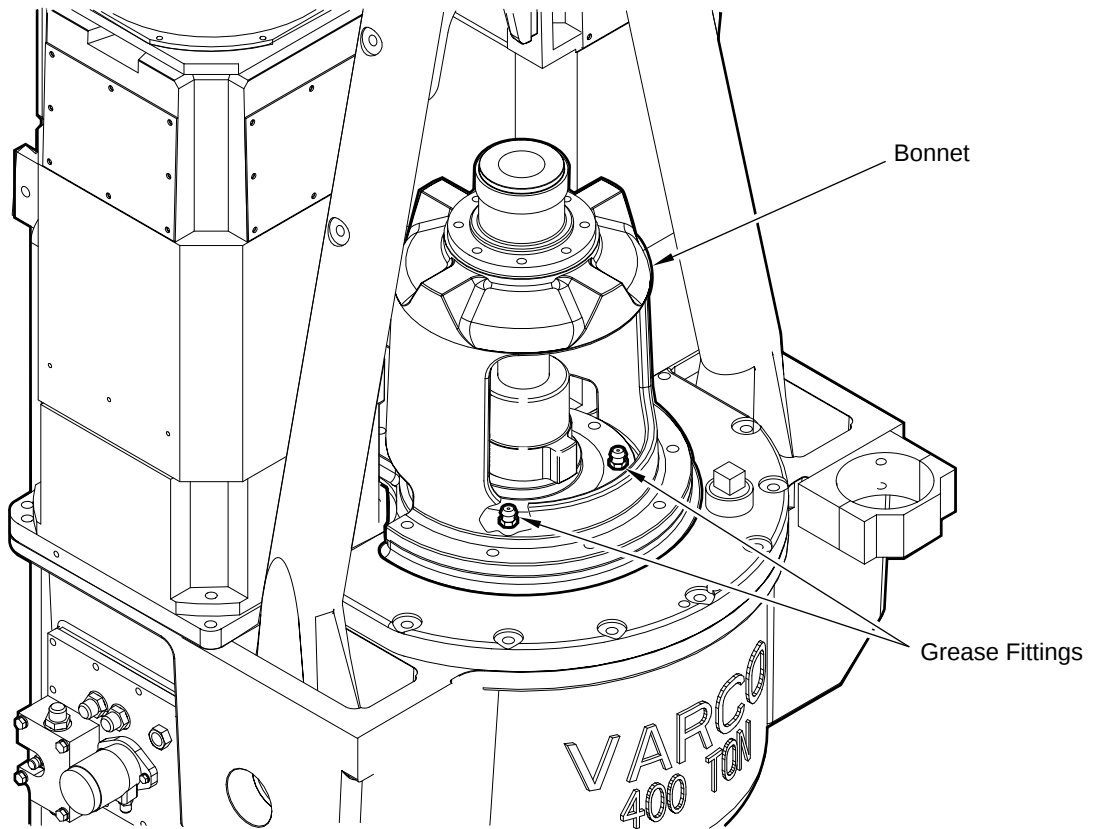
**Figure 4-14. Lubricating the wash pipe assembly**

# Lubricating the upper main body oil seals

Apply grease daily to the two grease fittings for the main body upper oil seals located inside the bonnet (Figure 4-15).



Grease the main body oil seals daily to prevent abrasive drilling mud from leaking into the main body.



**Figure 4-15. Lubricating the upper main body oil seals**



# Replacing the gearbox oil

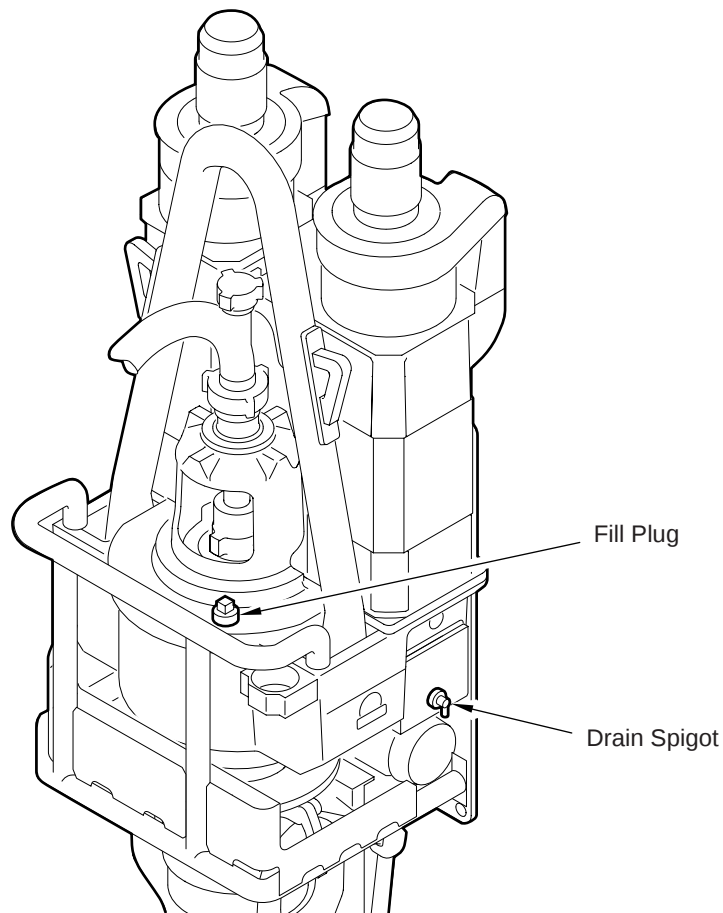
---

## Initial oil change

Drain and refill the gearbox after the first four weeks, or 500 hours of operation, whichever comes first (Figure 4-16). Replace the oil filter when changing the oil.



After every oil change, check for proper lubrication oil flow.



**Figure 4-16. Gearbox drain and fill locations**

## Oil capacity

The TDS-9S main body holds approximately 10-15 gallons of oil. Always fill the transmission to the middle of the sight glass. Use the following procedure to fill the transmission for the first time:

1. Use a hand pump to fill the gearbox to the top of the sight glass (*approximately* 10-15 gallons).
2. Operate the TDS 10-15 minutes and check the sight glass.
3. If the oil level is below the middle of the sight glass, add more oil until the level reaches the middle of the sight glass.

## Replacing the gearbox oil filter

---

Replace the gearbox oil filter at the same time the oil is changed (every three months). The filter is located on the bottom of the main body near the oil pump adapter plate (Figure 4-17).

## Lubricating the bail pins

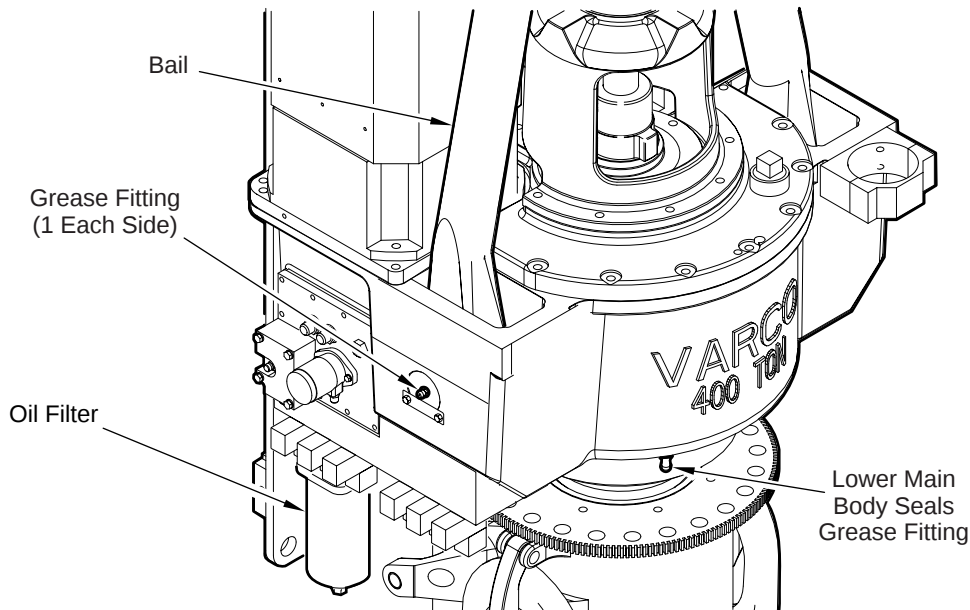
---

Apply grease weekly to the grease fittings for the bail pins located on the end of each pin (Figure 4-17).

## Lubricating the lower main body oil seals

---

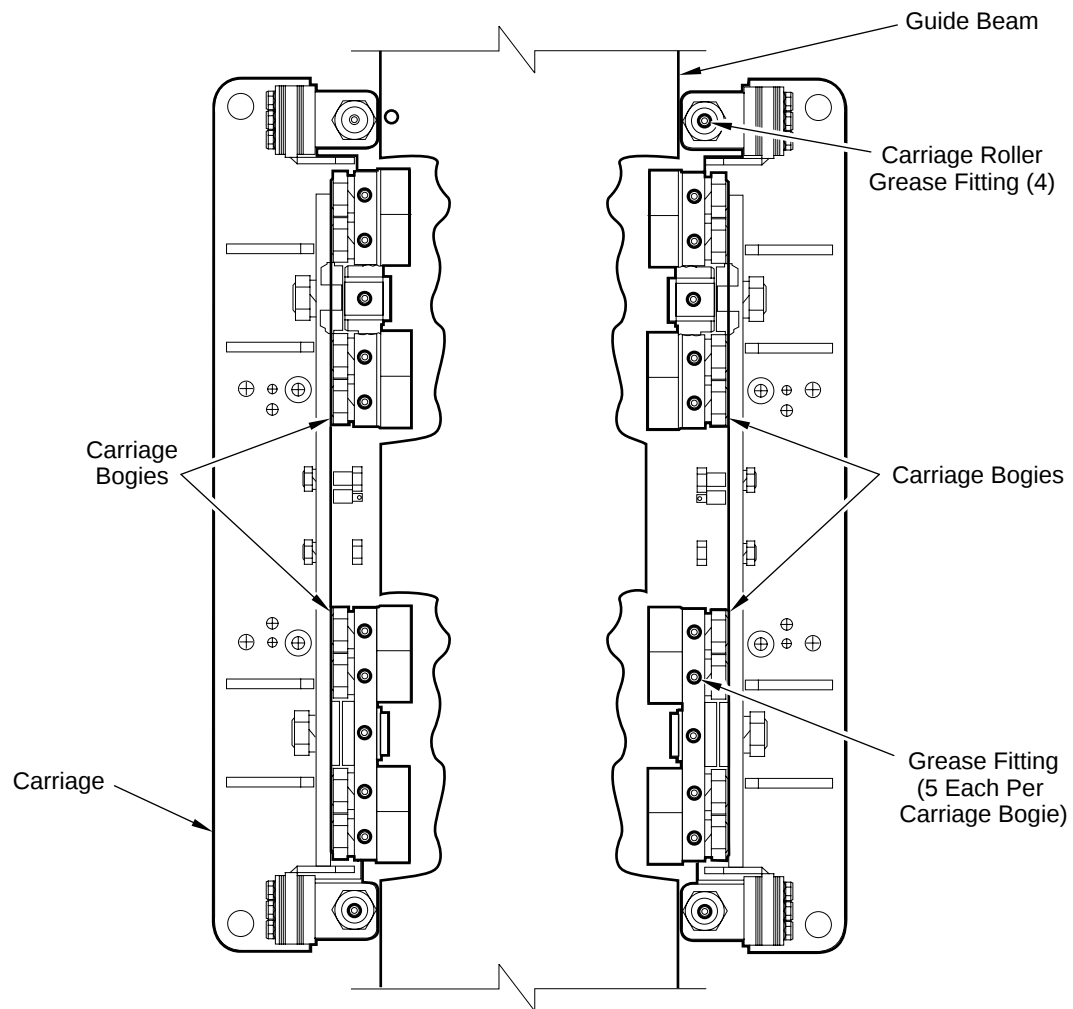
Apply grease weekly to the grease fitting for the lower main body oil seals located next to the shot pin assembly (Figure 4-17).



**Figure 4-17. Gearbox oil filter location**

# Lubricating the roller carriage assembly

Apply grease weekly to the 24 carriage assembly grease fittings (Figure 4-18). There are five fittings on each of four carriage bogies, as well as one fitting on each of four carriage rollers.

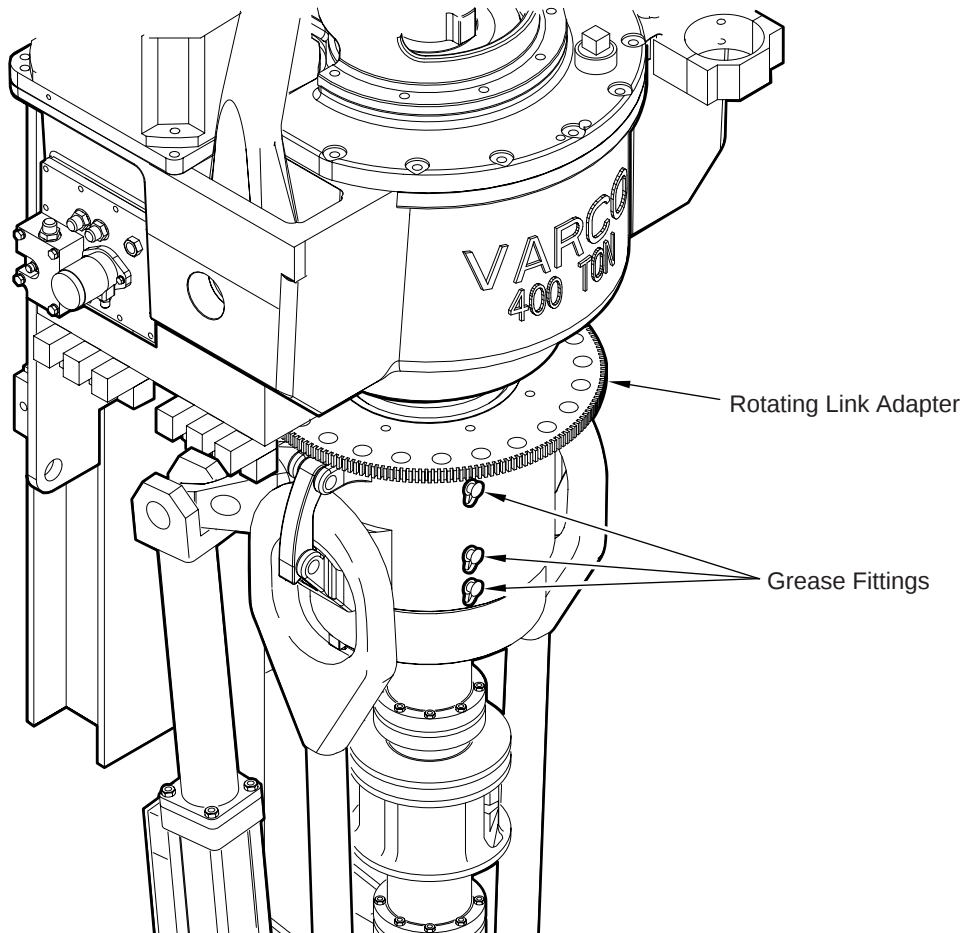


**Figure 4-18. Lubricating the roller carriage assembly**

# Lubricating the rotating link adapter

---

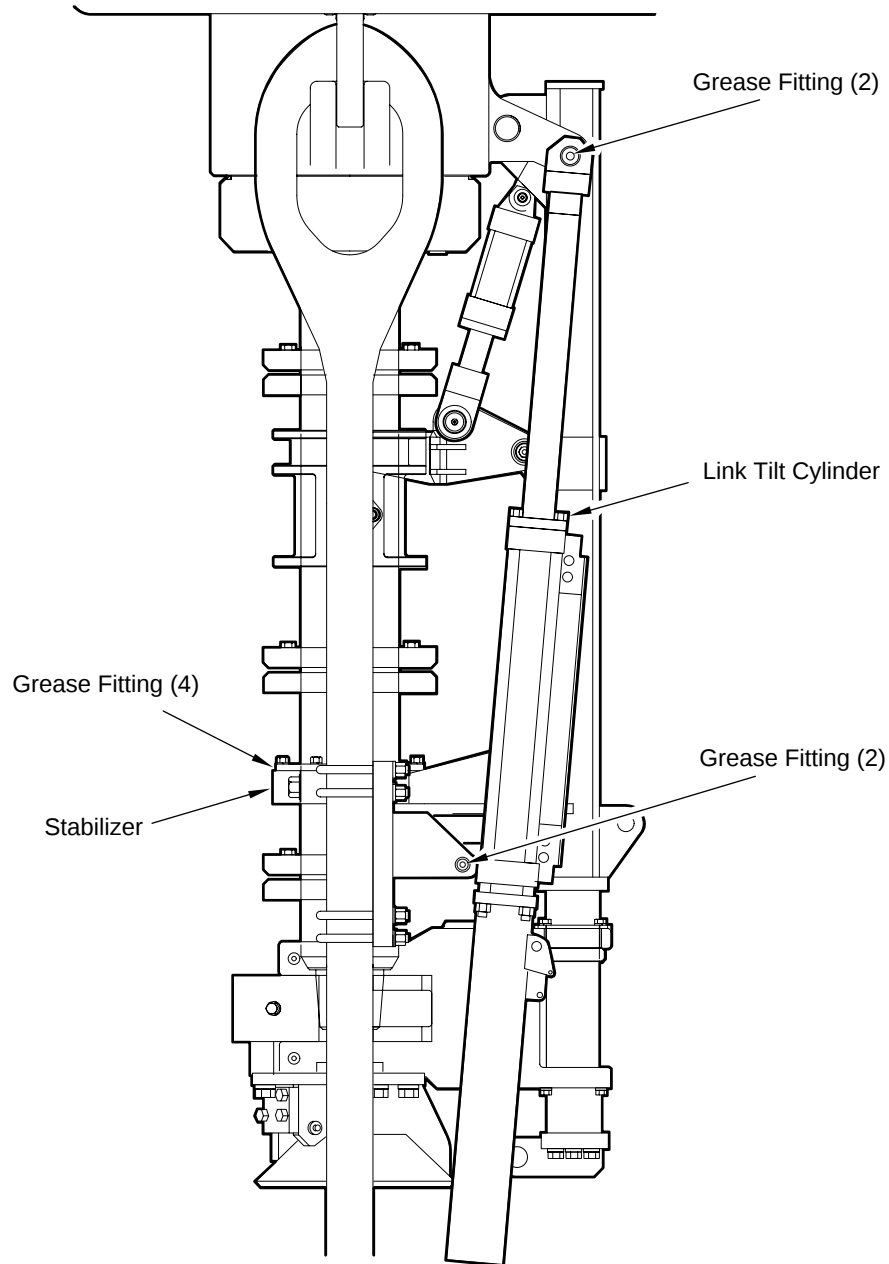
Apply grease weekly to the three grease fittings on the rotating link adapter (Figure 4-19).



**Figure 4-19. Lubricating the rotating link adapter**

# Lubricating the link tilt and PH-50 stabilizer bushing

Apply grease to the four link tilt grease fittings weekly (Figure 4-20). Lubricate the stabilizer bushing daily.

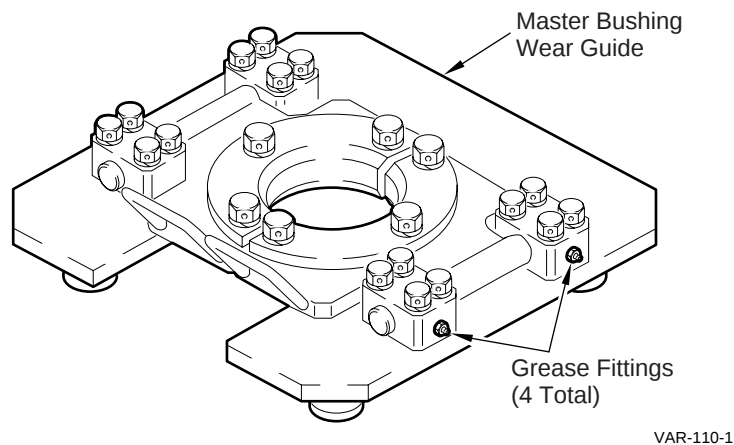


**Figure 4-20. Lubricating the link tilt and stabilizer bushing**

# Lubricating the elevator support and master bushing wear guide

---

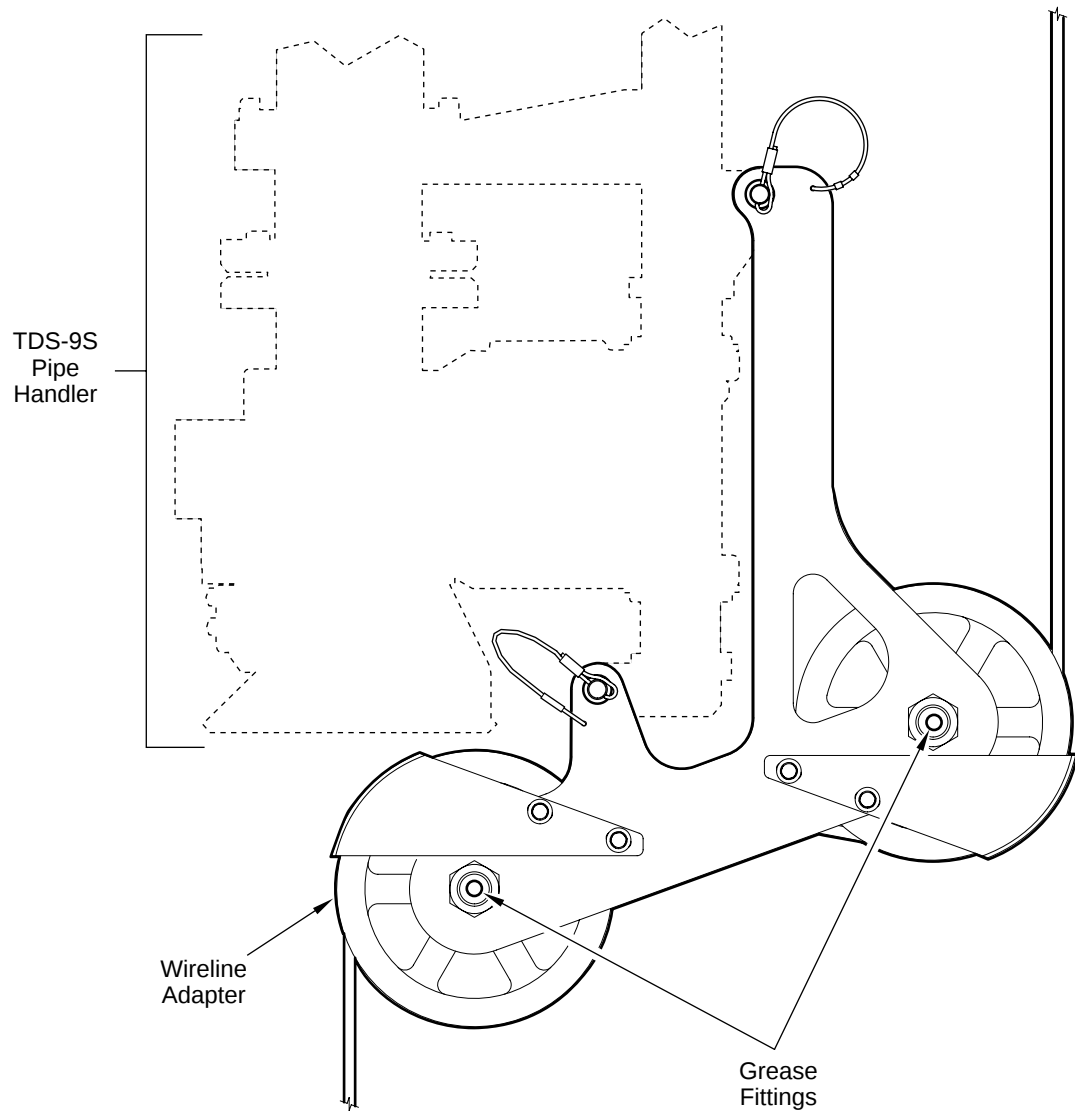
Apply grease to the seven grease fittings on the elevator support weekly. The master bushing wear guide has four fittings (Figure 4-21). Lubricate weekly. Inspect the guide ring periodically for wear or damage and replace it as necessary.



**Figure 4-21. Lubricating the master bushing wear guide**

# Lubricating the wireline adapter

Apply grease to the wireline adapter weekly. The wireline adapter has two fittings (Figure 4-22). Inspect the sheaves periodically for wear or damage and replace as necessary.



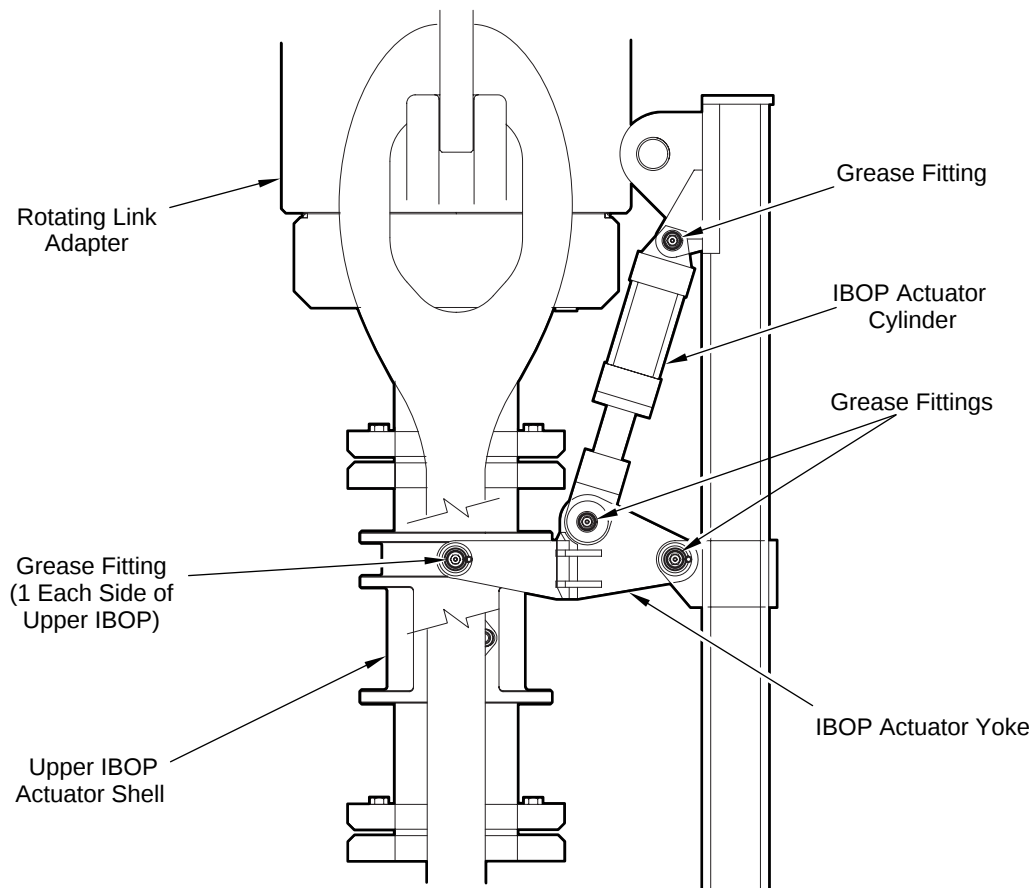
**Figure 4-22. Lubricating the wireline adapter**



# Lubricating the IBOP actuator yoke

---

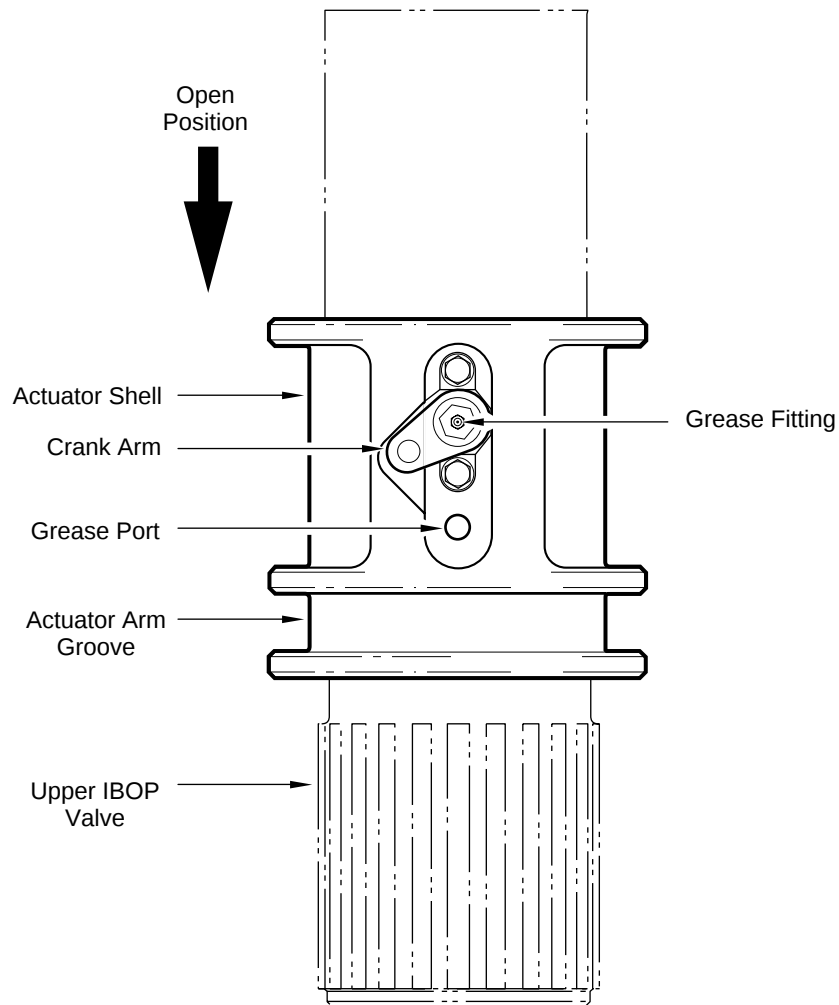
Apply grease to the five grease fittings on the IBOP actuator daily (Figure 4-23).



**Figure 4-23. Lubricating the IBOP actuator yoke**

# Lubricating the IBOP actuator crank

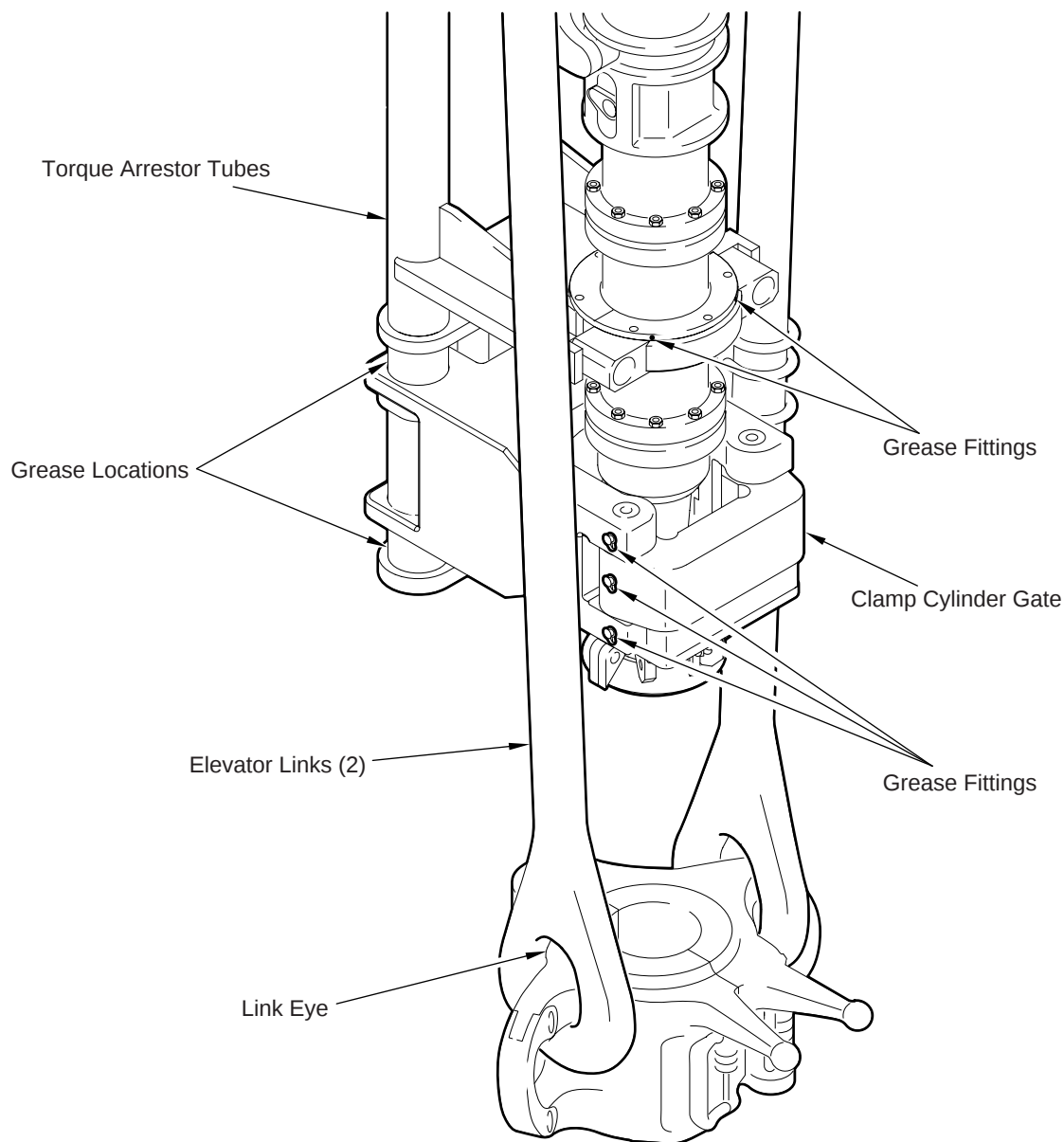
Apply grease daily to the two IBOP actuator crank grease fittings (Figure 4-24).



**Figure 4-24. Lubricating the IBOP actuator crank**

# Lubricating the torque arrestor tubes and clamp cylinder gate

Apply grease with a brush to the torque arrestor tubes and apply grease to the four clamp cylinder gate fittings weekly (Figure 4-25). Lubricate the link eye daily with pipe dope.



**Figure 4-25. Lubricating the torque arrestor and clamp cylinder gate**

# Chapter 5

## Maintenance

### General hydraulic system maintenance

---



***Release all hydraulic oil pressure by bleeding accumulators before disconnecting hydraulic lines. Turn the counterbalance valve to shutdown mode to bleed the hydraulic system. Hydraulic oil under pressure can penetrate skin and cause serious injury.***



***Before opening the hydraulic system, thoroughly clean work area, and maintain system cleanliness by promptly capping all disconnected lines. Dirt is extremely harmful to hydraulic system components and can cause equipment failure and subsequent injury to personnel.***



***Use care when handling components to prevent nicking close tolerance finishes.***

## Changing the hydraulic filter and oil

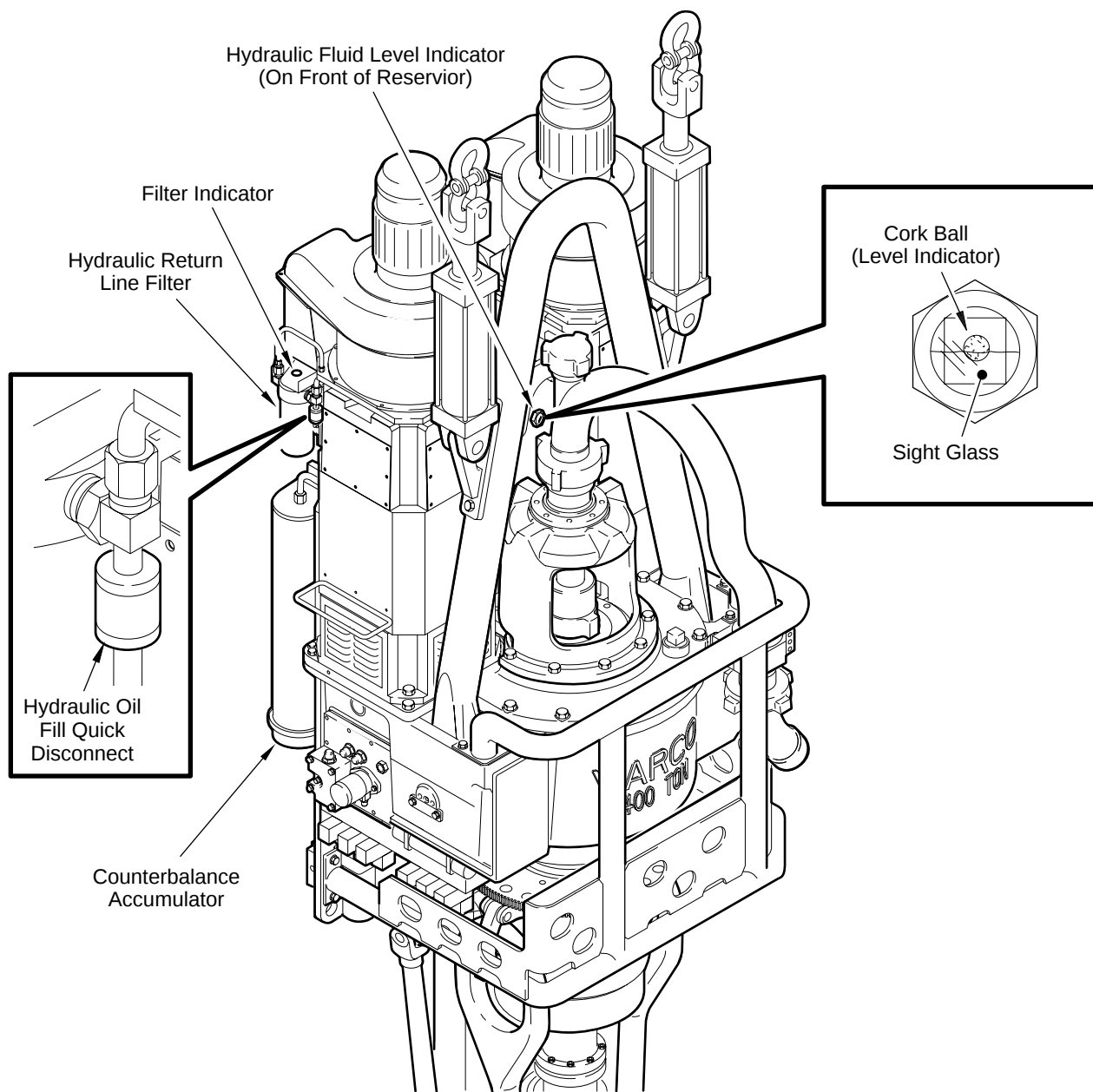
Check the pop-up indicator on the hydraulic filter daily. If the indicator has popped up, replace the spin-on filter element. Replace the filter element every three months or sooner if the indicator pops up (Figure 4-26).

Perform an oil analysis every three months and replace the hydraulic oil every twelve months, or sooner, based on the oil analysis results.



*Use care to prevent contamination from entering the hydraulic system during maintenance activities.*

The first oil change should be performed sooner than six months since new installations often contain metal contamination caused by connecting slightly damaged threaded parts.



**Figure 4-26. Hydraulic fluid reservoir and filter**

## Start-up procedure



*Only operate the hydraulic system when the TDS-9S is in the vertical position.*

Perform the following start-up procedure whenever restarting a hydraulic system in which a motor or pump has been removed and reinstalled:

1. Inspect all hydraulic system components (reservoir, hoses, valves, fittings, etc.) to make sure they are clean prior to filling with fluid.
2. Fill the hydraulic oil reservoir (see *Lubricant specifications*) with fluid passed through a 10 micron (nominal, no bypass) filter.
3. Check the reservoir level and add filtered fluid if necessary.
4. Fill the piston pump case with clean hydraulic oil (approximately 12 oz.)
5. Open the suction line shut off valves.
6. Jog start the AC drilling motors to verify correct rotation direction.

## Accumulator maintenance

---

The *Vender Documentation Package* contains the accumulator manufacturer's instructions for the TDS-9S hydraulic accumulators (Bulletin SB1630-M1). This bulletin contains all necessary maintenance, removal and replacement, and pre-charging instructions for the TDS-9S accumulators.

# Chapter 6

## Troubleshooting

### **Troubleshooting the AC drilling motors**

---

Refer to the AC motor manufacturer's manual located in the *Vender Documentation Package* .



# Troubleshooting the AC blower motors

There are two AC blower motors, one on top of each AC drilling motor. The following chart describes problems, probable causes and remedies.

*Table 4-5. Troubleshooting the AC blower motors*

| Symptom                                                         | Probable cause                 | Remedy                                                                     |
|-----------------------------------------------------------------|--------------------------------|----------------------------------------------------------------------------|
| Mechanical noise in blower.                                     | Loose impeller.                | Reinstall impeller and hub with threadlocking compound on screws.          |
|                                                                 | Faulty motor bearings.         | Repair or replace as needed.                                               |
| Blower runs intermittently.                                     | Faulty or loose wiring.        | Locate and repair as needed.                                               |
|                                                                 | Faulty motor starter           | Check for dirt or trash between starter coil. Repair or replace as needed. |
|                                                                 | Broken service loop conductor. | Use spare service loop conductor.                                          |
| Motor overheating, overtemp alarm stays on with blower running. | Incorrect blower rotation.     | Verify blower rotation is correct.                                         |
|                                                                 | Broken service loop conductor. | Use spare service loop conductor.                                          |

# Troubleshooting the hydraulic system

---

The following hydraulic troubleshooting section provides a schematic diagram and description for each TDS-9S hydraulic circuit. Following each schematic is a group of troubleshooting charts to help you quickly locate and correct hydraulic system problems.

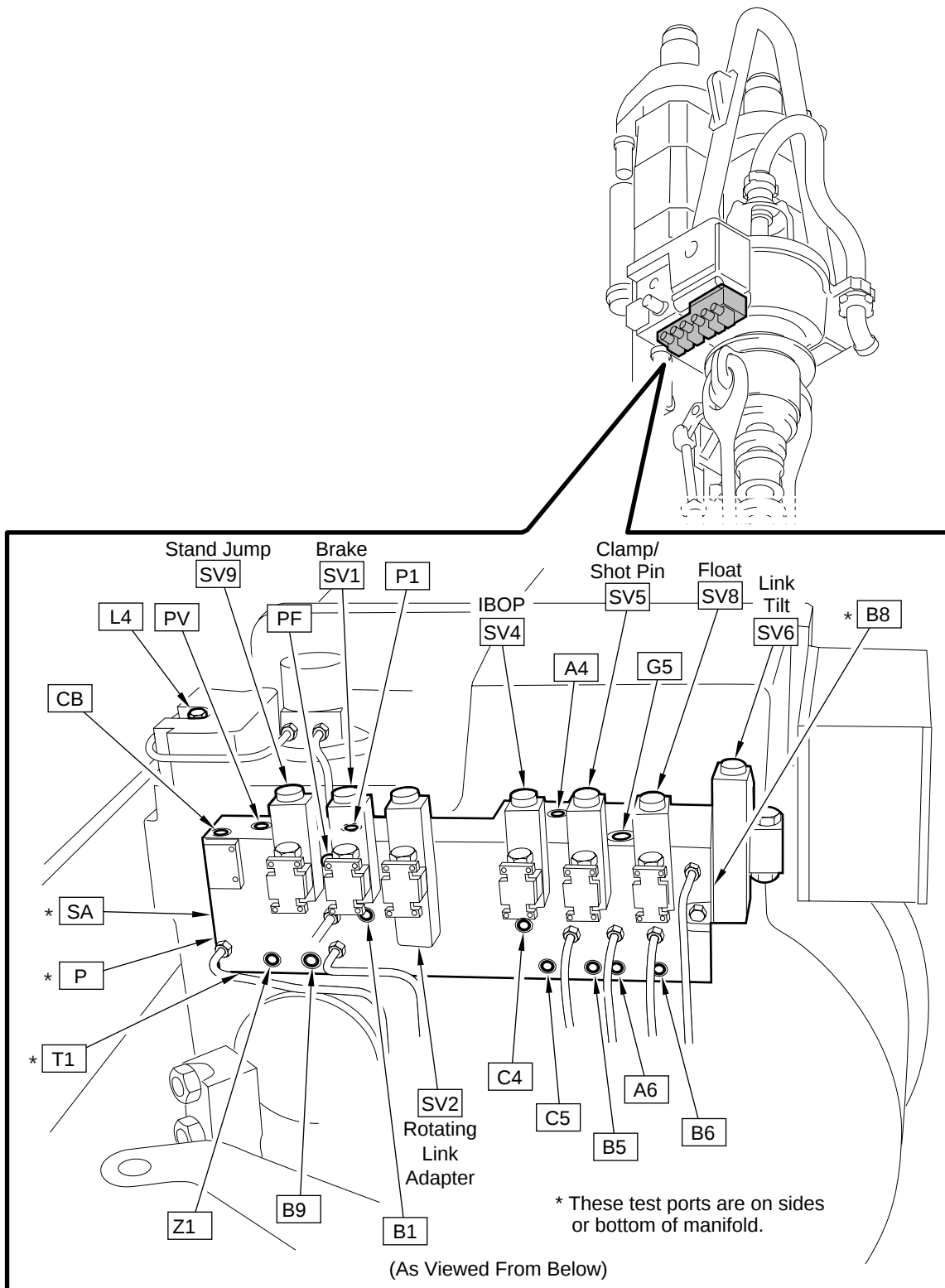
When performing hydraulic troubleshooting, be aware that:

- ☐ The electrical control system can be bypassed for troubleshooting by manually overriding the solenoid valve for each operational system.



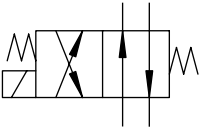
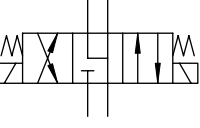
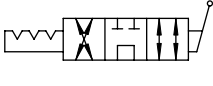
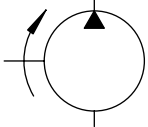
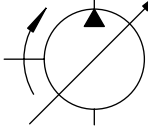
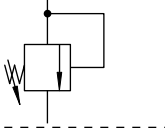
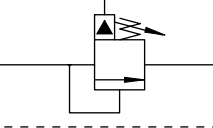
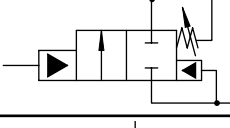
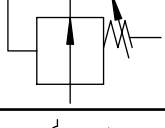
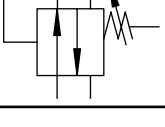
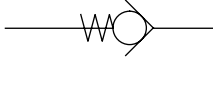
***Alert all personnel near the top drive before overriding a solenoid valve. When you override a solenoid valve, you bypass the safety interlock and top drive components will move possibly causing serious injury or death.***

- ☐ Test points shown in the hydraulic schematic with a box (e.g., A4) can be found on the manifold under the main body (Figure 4-27). There are also test points on the rotating link adapter motor.
- ☐ The system is preadjusted. Hydraulic problems are usually related to faulty valves, contamination, or other damage to the system rather than misadjustments. Changes to adjustments should be made only after all other possible causes have been eliminated.
- ☐ Table 4-6 identifies the schematic symbols used in this service manual section.

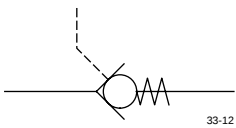
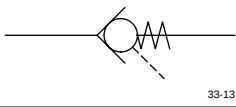
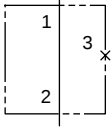
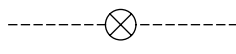
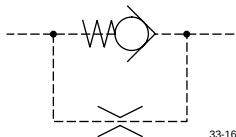
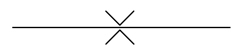
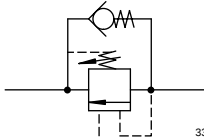
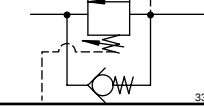
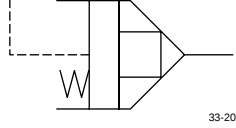
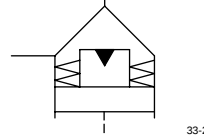
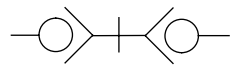


**Figure 4-27. Hydraulic manifold test ports**

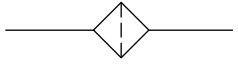
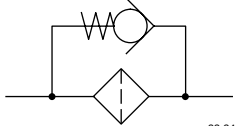
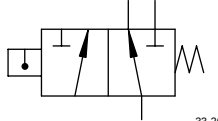
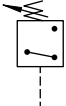
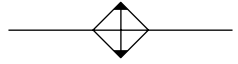
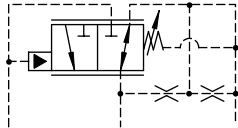
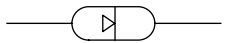
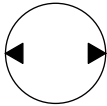
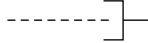
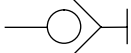
**Table 4-6. Hydraulic schematic symbols**

| Description                              |                                           | Symbol                                                                               | Schematic Reference                                                 |
|------------------------------------------|-------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| <b>Solenoid Operated Valves</b>          | 2 Position 4 Way Valves (Single Solenoid) |    | SV1, SV4, SV5, SV8, SV9                                             |
|                                          | 3 Position 4 Way Valves (Double Solenoid) |    | SV2, SV6                                                            |
| <b>Manual Valve (Rotary)</b>             | 3 Position 4 Way Valve                    |    | MV                                                                  |
| <b>Pumps</b>                             | Fixed Displacement                        |    |                                                                     |
|                                          | Variable Displacement                     |   |                                                                     |
| <b>Pressure Relief Valves</b>            | Standard Valve                            |  | RV2, A2R, B2R, SJR                                                  |
|                                          | Ventable Relief Valve                     |  | RV1                                                                 |
|                                          | Differential Unloading Valve              |  | UV1                                                                 |
| <b>Pressure Reducing Valve</b>           |                                           |  | PC1, PC4                                                            |
| <b>Pressure Reducing/Relieving Valve</b> |                                           |  | PCC                                                                 |
| <b>Chack Valve</b>                       |                                           |  | CDF, CTF, CV2, CTR, CDR, CXCD<br>Prefill valve assembly<br>CV1, CV2 |

**Table 4-6. Hydraulic schematic symbols (continued)**

| Description                               |                         | Symbol                                                                                       | Schematic Reference                |
|-------------------------------------------|-------------------------|----------------------------------------------------------------------------------------------|------------------------------------|
| <b>Check Valves</b>                       | Pilot-To-Open           | <br>33-12   | CKCB (Link Tilt)                   |
|                                           | Pilot-To-Close          | <br>33-13   | CA6, CB6, CV3, CV4<br>(Clamp Body) |
| <b>Cavity Plug</b>                        |                         | <br>33-14   | PC5                                |
| <b>Internal Plug</b>                      |                         | <br>33-15   |                                    |
| <b>Non Adjustable Flow Control Valves</b> |                         | <br>33-16  | CV1                                |
| <b>Non Adjustable Orifice</b>             |                         | <br>33-17 | Diameter in inches                 |
| <b>Counter-balance Valves</b>             | 3 Port (Internal Drain) | <br>33-18 | CBCA (Link Tilt Circuit)           |
|                                           | 4 Port (External Drain) | <br>33-19 | CWCK (Link Tilt Circuit)           |
| <b>Logic Cartridge</b>                    | Standard Cartridge      | <br>33-20 | LA^, LB6, LC5, LODC                |
|                                           | With Metering           | <br>33-21 | See Prefill Assembly               |
| <b>Quick Disconnect Coupling</b>          |                         | <br>33-22 |                                    |

**Table 4-6. Hydraulic schematic symbols (continued)**

| Description                             | Symbol                                                                                        | Schematic Reference                         |
|-----------------------------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------|
| <b>Non Bypass Filter</b>                | <br>33-23   | See Lube Oil Circuit                        |
| <b>Filter with Bypass</b>               | <br>33-24   | See Return Circuit                          |
| <b>Manual Shutoff Valve</b>             | <br>33-25   |                                             |
| <b>Thermostat</b>                       | <br>33-26   | Lube Oil Circuit                            |
| <b>Pressure Switch</b>                  | <br>33-27   | Lube Oil Circuit                            |
| <b>Heat Exchanger</b>                   | <br>33-28 | Hydraulic Circuit<br>(Inside Brake Housing) |
| <b>Pressure Compensator Control</b>     | <br>33-29 | Part of the Pump                            |
| <b>Hydro-Pneumatic Accumulator</b>      | <br>33-30 |                                             |
| <b>Hydraulic Motor (Bi-Directional)</b> | <br>33-31  |                                             |
| <b>Hydraulic Cylinder</b>               | <br>33-32 |                                             |
| <b>Tank (Reservoir)</b>                 | <br>33-33 |                                             |
| <b>Test Point</b>                       | <br>33-34 |                                             |

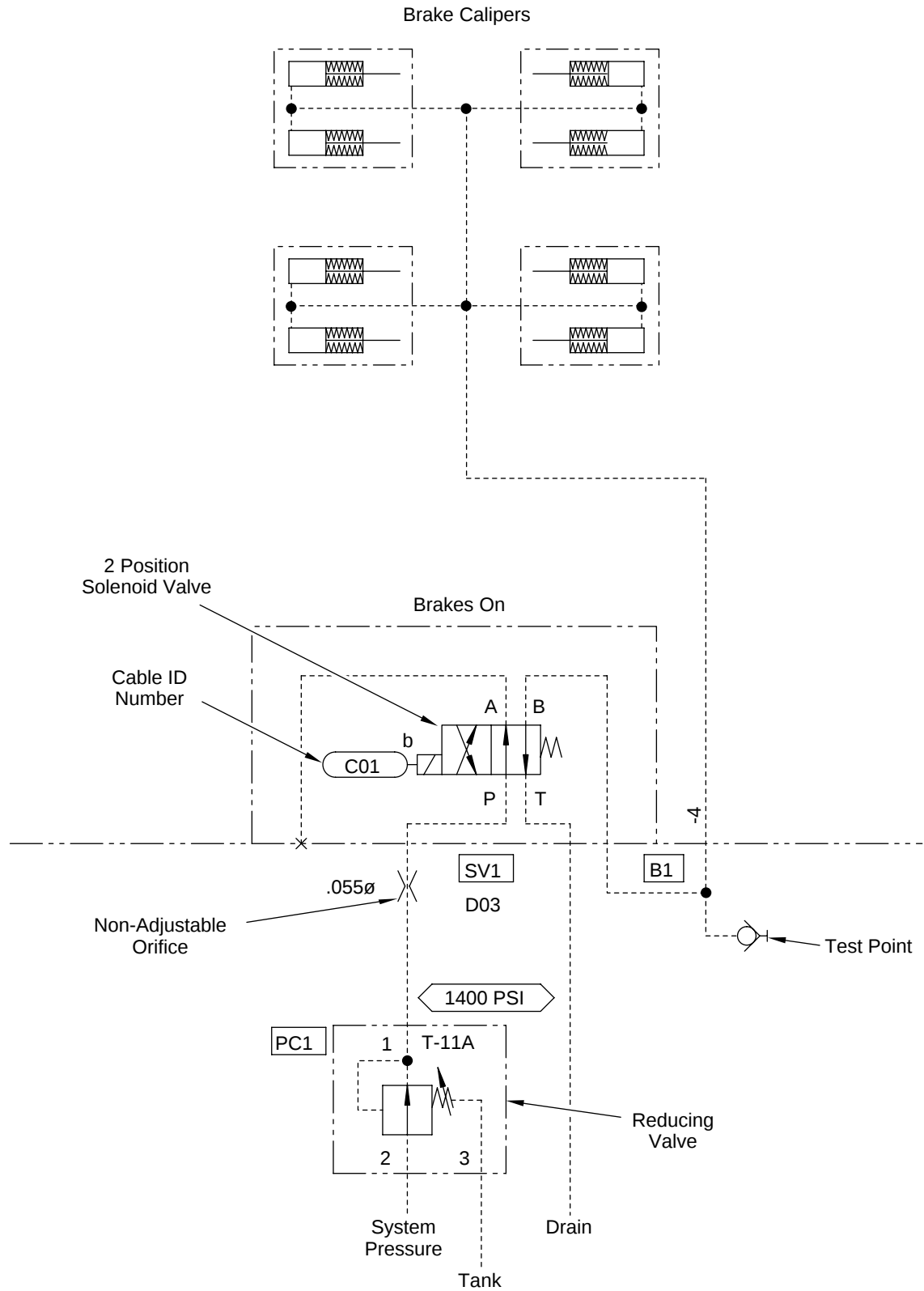
# Troubleshooting the AC drilling motor brakes

The AC drilling motor brakes are spring released and hydraulic pressure applied at 1,400 psi. The pressure reducing valve regulates the pressure to 1,400 psi. The solenoid valve operates to apply pressure, setting the brakes, or stop pressure to release the brakes.

*Table 4-7. Troubleshooting the AC drilling motor brakes*

| Symptom                                                      | Probable cause                                                   | Remedy                                                         |
|--------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------|
| Brake does not release.                                      | Directional valve is stuck.                                      | Test the valve and replace if necessary.                       |
| Brake releases but still drags.                              | Check valve is blocked or tube is pinched.                       | Replace the check valve or tube as required.                   |
|                                                              | Mechanical problems with brakes.                                 | Repair brake mechanism.                                        |
| Brakes do not engage or slip.                                | Hydraulic oil on brake pads.                                     | Check for hydraulic leaks and repair.                          |
|                                                              | Pressure is not 1,400 psi or does not rise crisply to 1,400 psi. | Reducing valve is plugged or needs to be adjusted or replaced. |
| Delay in brakes actuating after console switch is turned on. | Directional valve is stuck (check pressure at B1).               | Replace valve or check electrical signal.                      |
|                                                              | Hydraulic oil is contaminated.                                   | Replace hydraulic oil.                                         |
|                                                              | Pressured reducing valve is faulty.                              | Replace valve.                                                 |

Figure 4-28 shows the hydraulic circuit schematic for the AC drilling motor brakes. To test the system, turn the auto brakes switch on the driller's console to the ON position. Attach a pressure gauge to B1 in the manifold. The pressure reading should be 1,400 psi. If the reading is not 1,400 psi, adjust the pressure control reducing valve PC 1 to 1,400. Turn the auto brakes switch to the OFF position. The pressure reading should be very low. If the pressure is high, the solenoid valve might be sticking.



**Figure 4-28. Hydraulic circuit for AC drilling motor brakes**



# Troubleshooting the rotating link adapter (rotating head) motor

---

## Operation

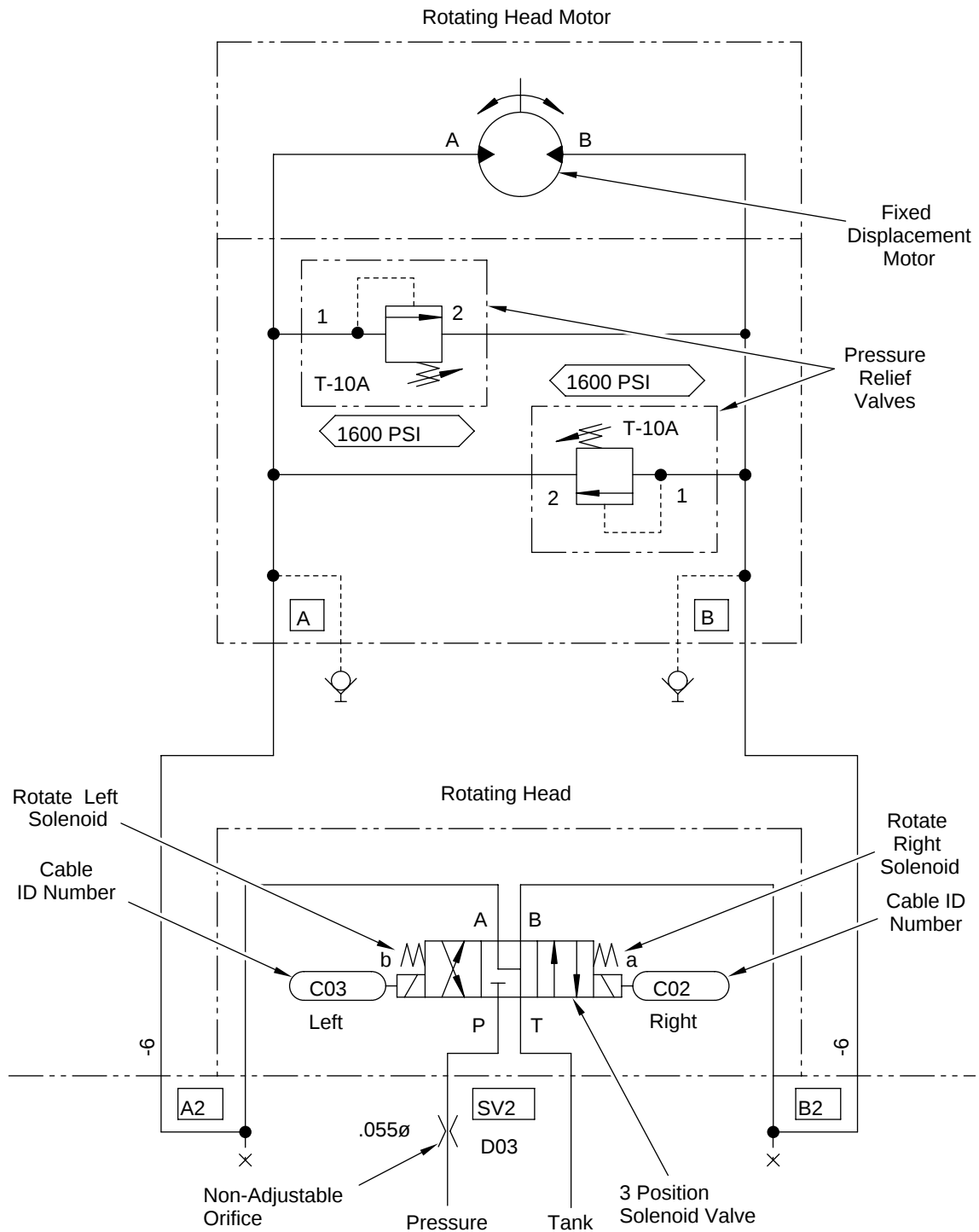
The three position directional valve controls the direction of the rotating head to the left or right. The pressure is applied to the A or B port of the hydraulic motor, depending on the selected direction. The auto return function is controlled by the processor and returns the tool to the home position.

## System test

The hydraulic circuit schematic for the rotating link adapter (rotating head) is shown in Figure 4-29. To test the system, operate the link adapter switch on the control panel. Verify both directions of rotation. The rotation speed is limited by the nonadjustable orifice. The torque is limited by the two relief valves.



The 1,600 psi test pressure at ports A and B is maximum load pressure. If the rotating link adapter is free to rotate, the load pressure will be less than maximum. The shot pin must be engaged to achieve full load pressure.



**Figure 4-29. Hydraulic circuit for the rotating link adapter motor**

**Table 4-8. Troubleshooting the rotating link adapter motor**

| <b>Problem</b>                         | <b>Probable cause</b>                                                                                        | <b>Remedy</b>                                                                                                                                                                                                                            |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tool does not rotate.                  | Direct control valve or relief valve is sticking.                                                            | Inspect, repair or replace the valve. Look for pressure changes when solenoid is energized. If there is no pressure change, try the manual override on the valve.                                                                        |
|                                        |                                                                                                              |  <i>When you override a directional valve, you bypass the safety interlock and top drive components move, possibly causing serious injury or death.</i> |
|                                        | Solenoid valve is not electrically operating.                                                                | Check electrical connections and valve functions.                                                                                                                                                                                        |
|                                        | Motor is worn out or gear teeth are broken.                                                                  | Replace the motor.                                                                                                                                                                                                                       |
|                                        | Shot pin is engaged.                                                                                         | Adjust the relief valve.                                                                                                                                                                                                                 |
|                                        | Mechanical interference.                                                                                     | Inspect and repair.                                                                                                                                                                                                                      |
|                                        | Directional valve does not shift.                                                                            | Test pressure left and right.<br>Replace the valve.                                                                                                                                                                                      |
|                                        | Fixed valve orifice is plugged.                                                                              | Clear orifice or replace the valve.                                                                                                                                                                                                      |
| Tool does not return to home position. | Hydraulic lines are damaged.                                                                                 | Replace hydraulic lines.                                                                                                                                                                                                                 |
|                                        | Valve is sticking or relief valve is out of adjustment.                                                      | Test pressures and inspect valves.<br>Adjust the relief valve as required.                                                                                                                                                               |
|                                        | Sensor is broken.                                                                                            | Replace sensor.                                                                                                                                                                                                                          |
|                                        | If the motor will drive normally, but not drive to the home position, the cause could be the control system. | Checkout control system.                                                                                                                                                                                                                 |
| Links are not synchronized.            | Counterbalance valves are out of adjustment.                                                                 | Adjust valves together-pressure is the same for all four valves.                                                                                                                                                                         |

# Troubleshooting the IBOP actuator cylinder

## Operation

The IBOP is in the open position under low hydraulic pressure, A4 = 500 psi, B4 and C4 = less than 100 psi. When you close the IBOP, high pressure is applied to the cylinder. A4 is less than 100 psi; B4 and C4 are 2000 psi. When the solenoid is de-energized, for opening the IBOP, A4 goes to 500 psi after a small time delay. B4 is less than 100 psi and C4 reaches 2000 psi after a small time delay. The time delay is operated by the time delay accumulator.

**Table 4-9. Troubleshooting the IBOP actuator cylinder**

| <b>Problem</b>                                | <b>Probable cause</b>                        | <b>Remedy</b>                                                          |
|-----------------------------------------------|----------------------------------------------|------------------------------------------------------------------------|
| Safety valve leaks.                           | Internal parts worn out.                     | Check for washouts or defective parts and repair or replace as needed. |
|                                               | Actuator not functioning properly.           | Check mechanical operation of actuator. Check reducing valves.         |
| Excessive vibration or wobble while rotating. | Yoke bushings or actuator bushings worn out. | Replace bushings.                                                      |
|                                               | Worn cam rollers.                            | Repair or replace rollers and roller brackets.                         |
| Cylinder does not actuate.                    | Pressure reducing valve plugged orifice.     | Test pressures and adjust or replace the pressure reducing valve.      |
|                                               | Accumulator not charged.                     | Test accumulator pressure and charge as required.                      |
|                                               | No system pressure.                          | Check hydraulic system operation.                                      |

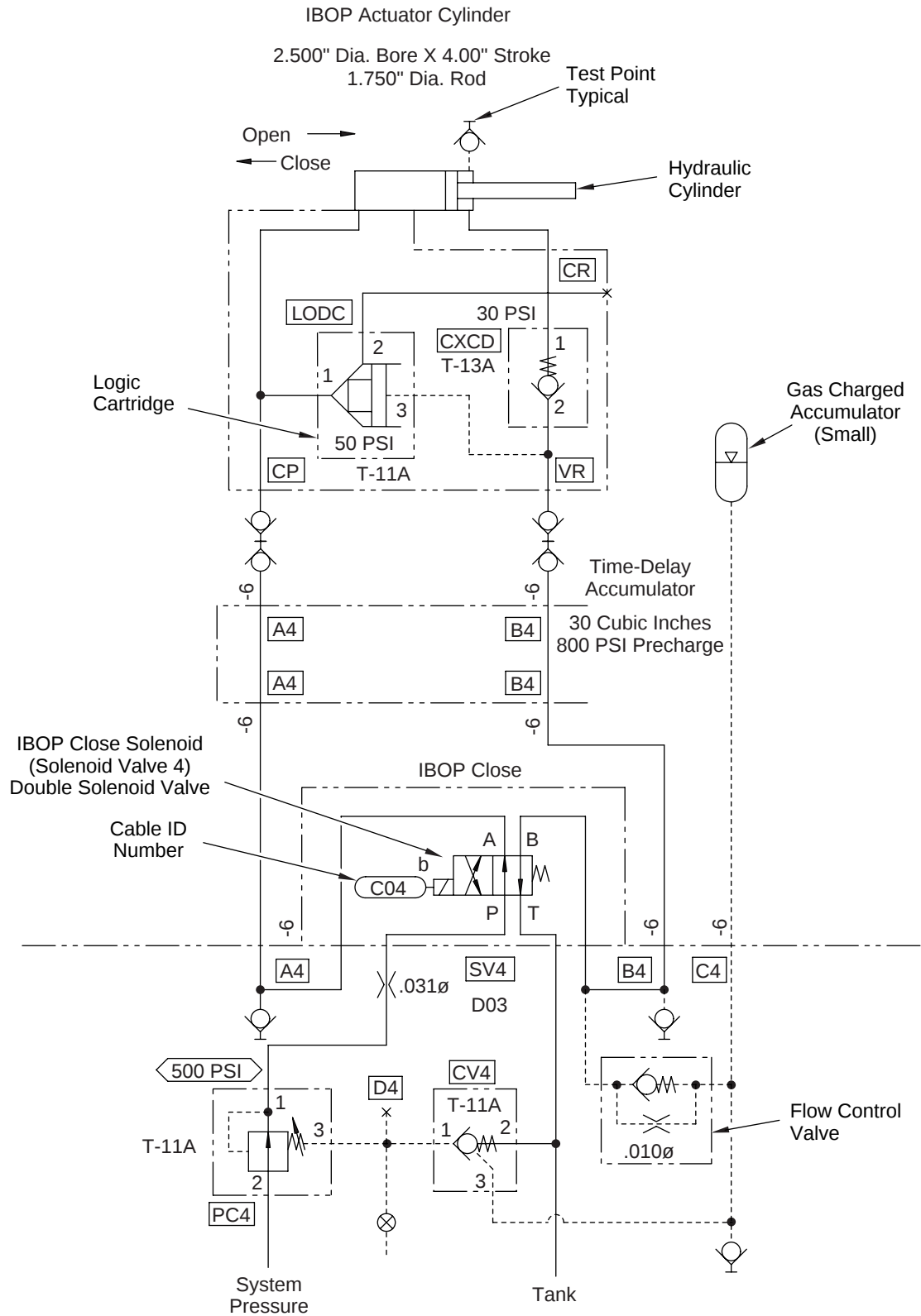
## System test

Figure 4-30 shows the hydraulic circuit schematic for the IBOP actuator cylinder. The IBOP is normally open.



***Alert all personnel near the shot pin, clamp, and link adapter before overriding a directional valve. When you override a directional valve, you bypass the safety interlock and top drive components move, possibly causing serious injury or death.***

To test the system, engage the IBOP and measure the pressure at B4 at 2,000 psi. The pressure at A4 drops to 500 psi. Open the IBOP and test the pressure at A4, which increases to 2,000 psi. The pressure at B4 and C4 drops to 500 psi.



**Figure 4-30. Hydraulic circuit for the IBOP actuator cylinder**

# Troubleshooting the shot pin cylinder and clamp cylinder

---

## Operation

The shot pin cylinder and clamp cylinder operation are interrelated and complex. The shot pin cylinder is different in that it has an extra port called the barrel port. The barrel port is back from the end of stroke which creates a valving effect. When the shot pin and clamp cylinders are not activated, the shot pin is fully retracted with full pressure and the clamp cylinder is retracted with 500 psi.

When you energize the clamp cylinder, the shot pin cylinder is actuated against the rotating gear and it may miss one of the 24 holes. The control system starts pulsing the link adapter to move slowly until the shot pin engages a hole on the rotating gear. The shot pin cylinder pressure is limited by the relief valve until the cylinder passes through one of the holes. Once the pin engages the hole, full system pressure is applied to C5 which opens valve CV5, applying full pressure to the clamp cylinder to close.

When the clamp cylinder is de-energized, the clamp releases and the shot pin pulls out.

## System test

Figure 4-31 shows the hydraulic circuit schematic for the shot pin cylinder and clamp cylinder. At rest the pressure at C5 is 2,000 psi, B5 is less than 100 psi, CP is less than 100 psi, and CR is 500 psi.







***Alert all personnel near the shot pin, clamp, and link adapter before overriding a directional valve. When you override a directional valve, you bypass the safety interlock and top drive components move, possibly causing serious injury or death.***

When you energize solenoid valve SV5, using the manual override, pressure increases to the barrel of the shot pin cylinder. The pressure is controlled by a .031 pressure reducing valve that prevents the shot pin from putting full force on the link adapter surface until the pin engages in one of the holes.

Pressure at B5 is 200 psi (limited by the relief valve), C5 is less than 100 psi, G5 is less than 100 psi, CP is less than 100 psi, and CR is less than 100 psi.

Once the shot pin engages the hole, full pressure is applied in C5 to control valve CV5 open for clamp. Pressure at B5 is 2,000 psi, C5 is 2,000 psi (forces valve CV5 open for clamp), G5 is less than 100 psi, CP is 2,000 psi, and CR is less than 100 psi.

When solenoid valve SV5 is de-energized, the shot pin cylinder withdraws the shot pin, and the clamp disengages at the same time. The circuit returns to rest conditions.

**Table 4-10. Troubleshooting the shot pin cylinder and clamp cylinder**

| <b>Problem</b>                                          | <b>Probable cause</b>                                                                                                                                                                                                                                                                                    | <b>Remedy</b>                                                                   |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Shot pin does not engage.                               | Solenoid valve is not operating or relief valve is not adjusted.                                                                                                                                                                                                                                         | Check electrical actuation and test pressure. Adjust as required.               |
|                                                         | Abnormal pressure change at B5 and C5 indicates valve problem.                                                                                                                                                                                                                                           | Replace directional control valve.                                              |
|                                                         | Normal pressure change indicates plumbing or shot pin cylinder are faulty.                                                                                                                                                                                                                               | Repair plumbing or shot pin cylinder.                                           |
| Shot pin applies excessive force to rotating head gear. | Relief valve is not operating or out of adjustment.                                                                                                                                                                                                                                                      | Test pressures and adjust as required.                                          |
| Clamp cylinder does not actuate.                        | No pressure or reduced pressure at the cylinder.                                                                                                                                                                                                                                                         | Test pressures and adjust and repair as required.                               |
|                                                         | Cylinder is damaged.                                                                                                                                                                                                                                                                                     | Inspect cylinder and repair or replace.                                         |
|                                                         | Note: To provide high pressure to the clamp circuit, pressure at C5 must be 2,000 psi and G5 must be less than 100 psi. If this condition is met, pressure at CP should increase from less than 100 psi to higher than 2,000 psi. If not, check the plumbing, rotating link adapter, and clamp cylinder. | Repair plumbing, rotating head, or clamp cylinder.                              |
|                                                         | While clamping, pressure at CR should be 2.7 times the pressure at CP. When the dies contact the pipe, pressure at CR should be less than 100 psi. If the pressure does not fade, check valve CNEC for contamination.                                                                                    | Clean or repair CNEC valve.                                                     |
| Shot pin engages but clamp cylinder does not activate.  | Control valve not operating.                                                                                                                                                                                                                                                                             | Check pressure at C5. Replace valve CV5 if required or the regenerate manifold. |

# Troubleshooting the link tilt cylinders

---

## Operation

Figure 4-32 shows the hydraulic circuit schematic for the link tilt cylinders. The solenoid valve SV6 operates two cylinders with load holding manifolds.

When the solenoid valve SV6 is actuated to the mousehole position, full pressure is applied through E6 to the link tilt cylinder to move the links to the mousehole position. When solenoid valve SV6 is actuated to the drill down position, full pressure is applied through G6 to move the cylinder to the drill down position.

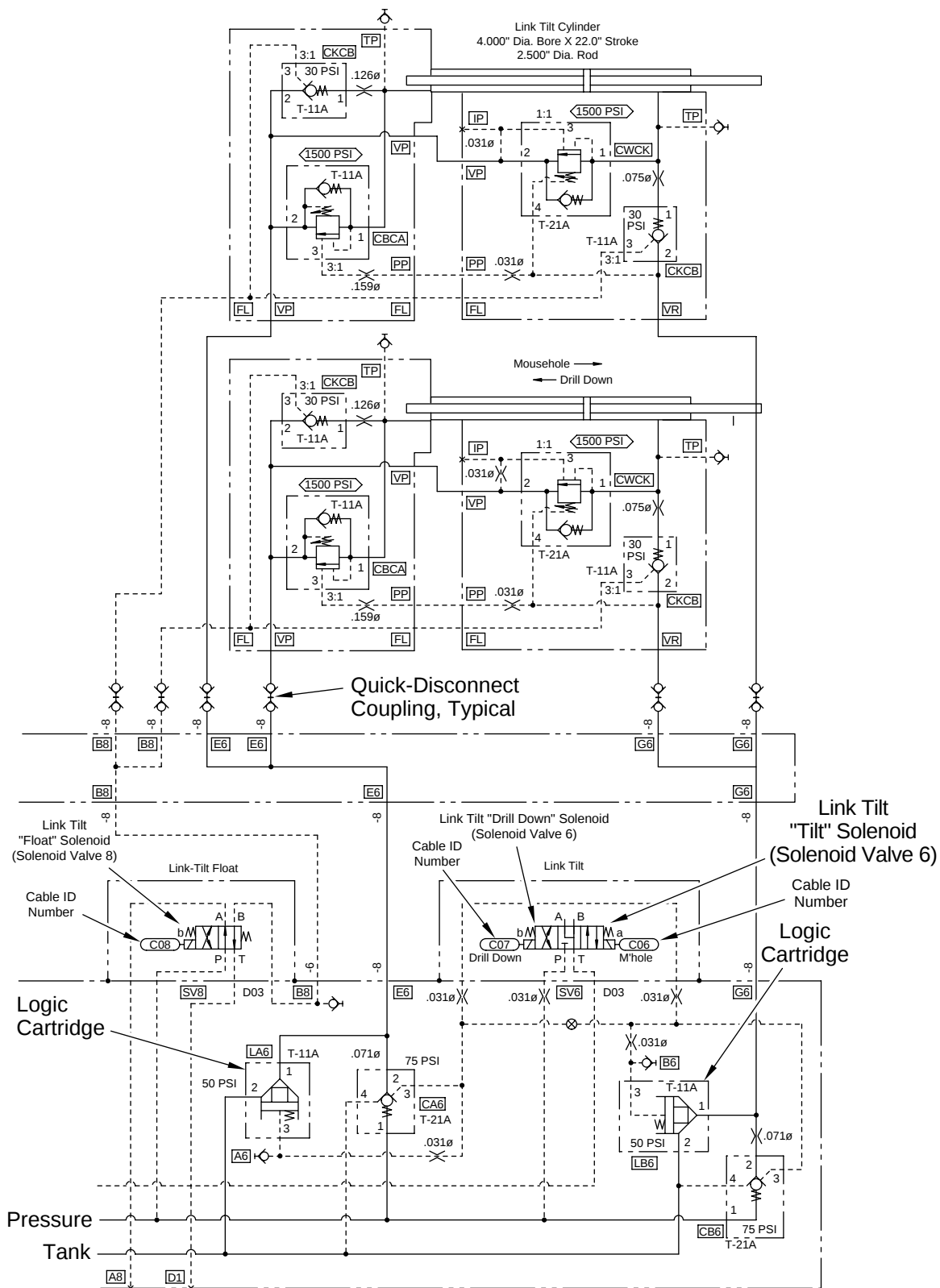
The link tilt float solenoid valve SV8 releases pressure from the cylinder to allow the link tilt to move to the well center position.

## System test

For the link tilt circuit, there is nothing to adjust on the manifold. The four load-holding valves are adjusted in pairs, two for the rod end and two for the piston end. Adjusting the valves at the same time assures the link tilt operation is synchronized.



***Alert all personnel near the shot pin, clamp, and link adapter before overriding a directional valve. When you override a directional valve, you bypass the safety interlock and top drive components move, possibly causing serious injury or death.***



**Figure 4-32. Hydraulic circuit for the link tilt**

Use the following procedures to test the link tilt cylinder:

1. From the drillers console, set the link tilt to the mousehole position, which energizes the solenoid valve SV6 and drives the link tilt cylinder to full extension.
2. The cylinder goes to full extension and the pressure at test port TP is 2000 psi.
3. Set the system to a neutral position and observe the pressure drop. Adjust the pressure at relief valve CBCA to approach 1,500 psi.



This is an iterative process. Continue to set the driller's console control to mousehole and neutral, taking present and delayed pressure readings.



*Turning the relief valve counterclockwise increases the pressure.*

4. Both system rod and piston relief valve pressures at TP and FL are 1,500 psi for balanced hydraulic system operation. Adjust relief control valves CBCA and CWCK for rod and piston pressure at 1,500 psi. The piston relief valves are set at the pistons fully extended and the rod relief valves are set at the pistons fully retracted.

**Table 4-11. Troubleshooting the link tilt**

| <b>Problem</b>                                                     | <b>Probable cause</b>                                                                                           | <b>Remedy</b>                                           |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| Drill pipe elevator does not reach mouse hole/derrickman position. | Link clamp incorrectly adjusted.                                                                                | Readjust.                                               |
| Links drift when valve is released.                                | Pressure at B8 does not decay to less than 100 psi.                                                             | Replace pilot to open check valve.                      |
|                                                                    | Pilot to open check valve is stuck open or contaminated.                                                        | Replace pilot to open check valve.                      |
|                                                                    | Faulty cylinder seal.                                                                                           | Replace seal.                                           |
|                                                                    | Load holding relief valves are out of adjustment, stuck open, or contaminated.                                  | Adjust or replace load holding relief valve.            |
| Drill pipe elevator does not float back to center position.        | Use manual override – if link tilts, the problem is electrical. If links do not tilt, the problem is hydraulic. | Test solenoid and connectors.<br>Test hydraulic system. |
| Link tilt does not tilt.                                           | Solenoid valve is not shifting.                                                                                 | Check electrical continuity.                            |
| Links do not move together.                                        | Load holding valves are out of adjustment.                                                                      | Adjust pressure for all four valves to 1,500 psi.       |

# Troubleshooting the counterbalance system

---

Figure 4-33 shows the hydraulic circuit schematic for the counterbalance system. The accumulator, with precharge pressure of 900 psi, along with check valve CV3, maintains a hydraulic pressure. Refer to the vendor documentation material located in the *Vendor Documentation Package*, for the gas charging procedure for the accumulator.

A three-position manually operated valve controls counterbalance operation for rig-up, run, and shut down modes. In the rig-up mode, system pressure is applied to XC and the prefill valve, causing both cylinders to extend. When the cylinders extend, you make up the mechanical connection to the bail. In the run mode, for counterbalance operation, approximately 1,600 psi is needed at the counterbalance cylinders to lift the TDS-9S off the hook.

The optional stand jump feature is controlled by solenoid valve SV9. With the counterbalance in the run mode and the stand jump switch on, additional pressure of approximately 300 psi is applied to over the normal counterbalance pressure to lift the TDS-9S and drill string off the hook.

In the shutdown mode, the hydraulic system bleeds down the system accumulator and the counterbalance accumulator pressure.

## Counterbalance testing

For the counterbalance operation, a lift of approximately 30,000 lb is achieved with a pressure of 1600 psi at CB. Perform the following steps to adjust the force:

1. Set the counterbalance mode valve to the RUN mode. Set the pressure control valve PCC to the minimum setting (fully counterclockwise).
2. Test the pressure at port B9. There should be a 0 psi reading.
3. Test the pressure at port CB. Observe the position of the top drive on the hook.
4. Adjust the pressure at pressure control valve PCC clockwise, observing pressure at CB, until the top drive just lifts off the hook. Back off the pressure 25 psi, as the top drive rests on the hook.

**Figure 4-33. Hydraulic circuit for the counterbalance system**



## Stand jump testing

For the optional stand jump feature, a lift of about 33,000 lb is achieved with a pressure of approximately 1800 psi at CB. The additional 300 psi pressure over the normal counterbalance pressure is provided by energizing the stand jump solenoid valve SV9. Perform the following steps to adjust the pressure:

1. Set the counterbalance mode switch to RUN and engage the stand jump switch. Test the pressure at port CB and B9. Adjust relief valve SJR fully counterclockwise to the minimum setting.
2. Slowly increase the pressure at CB by adjusting relief valve SJR clockwise until the bail lifts off the hook with a stand of pipe in the elevator.



Adjust relief valve SJR slowly to allow pressure at CB to stabilize.

**Table 4-12. Troubleshooting the counterbalance system**

| <b>Problem</b>                    | <b>Probable cause</b>                | <b>Remedy</b>                                                             |
|-----------------------------------|--------------------------------------|---------------------------------------------------------------------------|
| Counterbalance does not function. | Cylinder damaged. Seal leaks.        | Inspect cylinder and repair or replace seal.                              |
|                                   | No hydraulic pressure.               | Test pressure and adjust pressure reducing valve.                         |
|                                   | Solenoid valve SV9 is not operating. | Test electrical and hydraulic operation. Replace or repair as applicable. |
|                                   | PCC is not operating.                | Replace the valve.                                                        |
|                                   | Relief valve is not operating.       | Replace the valve.                                                        |
|                                   | Precharge on accumulator is low.     | Charge accumulator.                                                       |
| Stand jump does not function.     | Cylinder damaged. Seal leaks.        | Inspect cylinder and repair or replace seal.                              |
|                                   | No hydraulic pressure.               | Test pressure and adjust pressure reducing valve.                         |
|                                   | Solenoid valve SV9 is not operating. | Test electrical and hydraulic operation. Replace or repair as applicable. |
|                                   | PCC is not operating.                | Replace the valve.                                                        |
|                                   | Relief valve is not operating.       | Replace the valve.                                                        |
|                                   | Precharge on accumulator is low.     | Charge accumulator.                                                       |

# Troubleshooting the hydraulic power unit and reservoir

---

## Operation

Figure 4-34 shows the onboard hydraulic power unit schematic. A 10 HP electric motor drives the variable displacement pump and the fixed displacement pump. A pressure compensator controls the variable displacement pump.

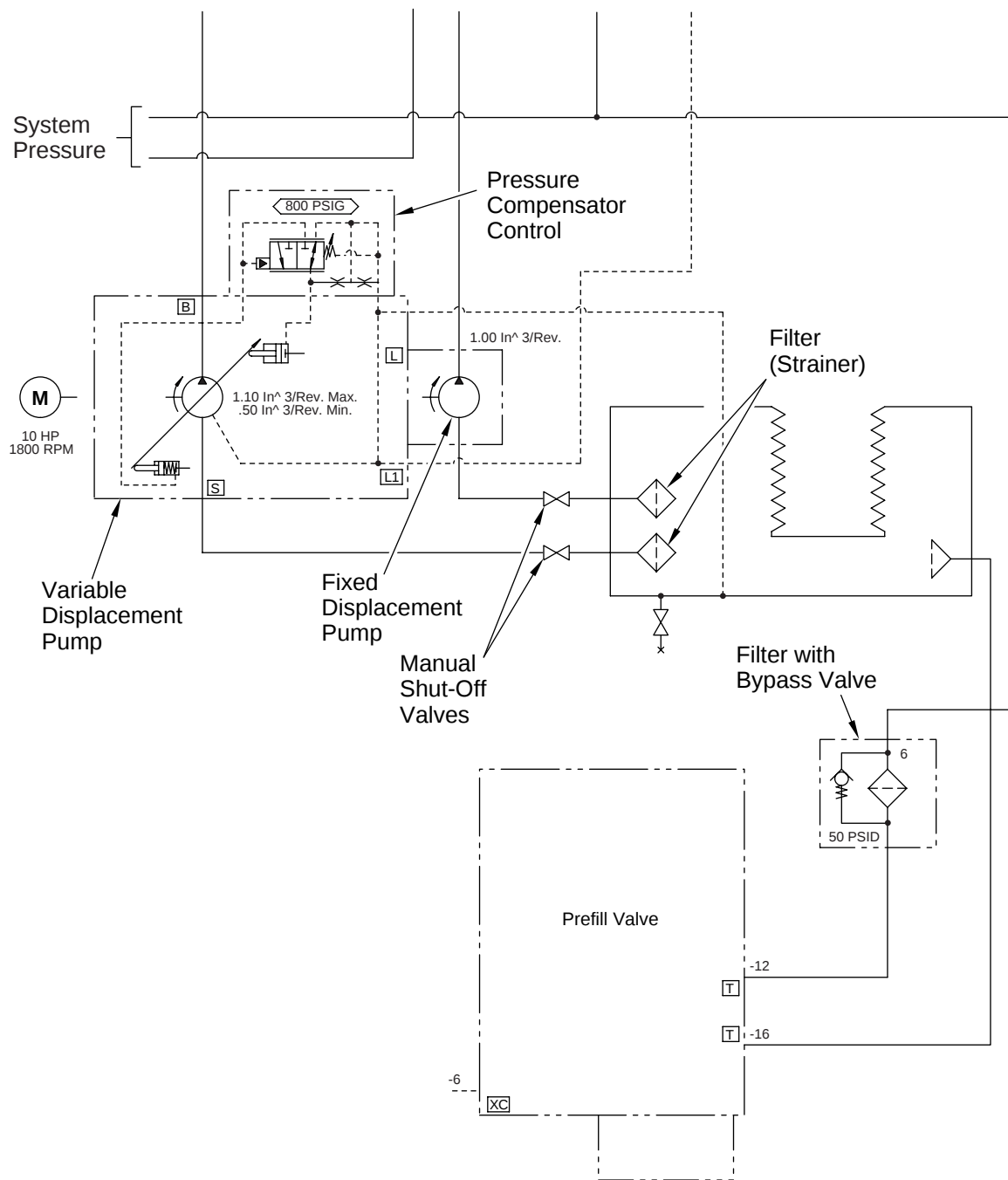
The fixed displacement pump provides hydraulic power to operate the lubrication pump motor. Pressure can be tested at port PF. Relief valve RV2 limits the driving pressure of the lube oil circuit.

The variable displacement pump provides hydraulic power to the counterbalance cylinders, drilling motor brakes, rotating link tilt motor, IBOP actuator cylinder, shot pin cylinder, and link tilt cylinders.

## System test

Test the circuit pressure at port PV. Relief valves RV1 and UV1 are a part of the circuit. UV1 is a differential unloading valve, which can be pressure checked at port Z1.

RV2 is set at 400 psi and can be tested at PF. Test the pressure at PV to confirm the relief valve RV1 is set at 800 psi. The differential unloading valve UV1 is tested at Z1 to confirm the pressure is 2,000 psi.



**Figure 4-34. Hydraulic circuit for the hydraulic power unit and reservoir**

**Table 4-13. Troubleshooting the hydraulic power unit and reservoir**

| <b>Problem</b>                       | <b>Probable cause</b>                                                                   | <b>Remedy</b>                                                                                                                                                 |
|--------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hydraulic system overheating.        | Relief valves out of adjustment.                                                        | Test pressures and adjust relief valves.                                                                                                                      |
|                                      | Unloading valve is not working.                                                         | Test and adjust UV1 or replace unloading valve.                                                                                                               |
|                                      | Counterbalance mode valve left in shut down position too long and pressure bleeds down. | Check system pressure.                                                                                                                                        |
|                                      | No precharge in system accumulator.                                                     | Charge system accumulator.                                                                                                                                    |
| Hydraulic components do not operate. | System pressure is down.                                                                | Test pumps and motors. Test relief valve pressures. Adjust as required. Check for leaks, loose fittings, loose cylinders, worn hoses, fluid levels and seals. |
|                                      | Piston pump is not working.                                                             | Replace the pump.                                                                                                                                             |
|                                      | Flexible coupling is damaged.                                                           | Replace the flexible coupling.                                                                                                                                |
|                                      | Lubrication pump is not working.                                                        | Replace the lubrication pump.                                                                                                                                 |
|                                      | Pressure at UV1 is too low.                                                             | Adjust pressure at UV1.                                                                                                                                       |
|                                      | Pumps are rotating in the wrong direction.                                              | Inspect hydraulic connections and correct rotation.                                                                                                           |
|                                      | Suction valve closed.                                                                   | Open suction valve.                                                                                                                                           |
|                                      | Low oil level in reservoir.                                                             | Fill hydraulic reservoir.                                                                                                                                     |

# Troubleshooting the gearbox lubrication hydraulic system

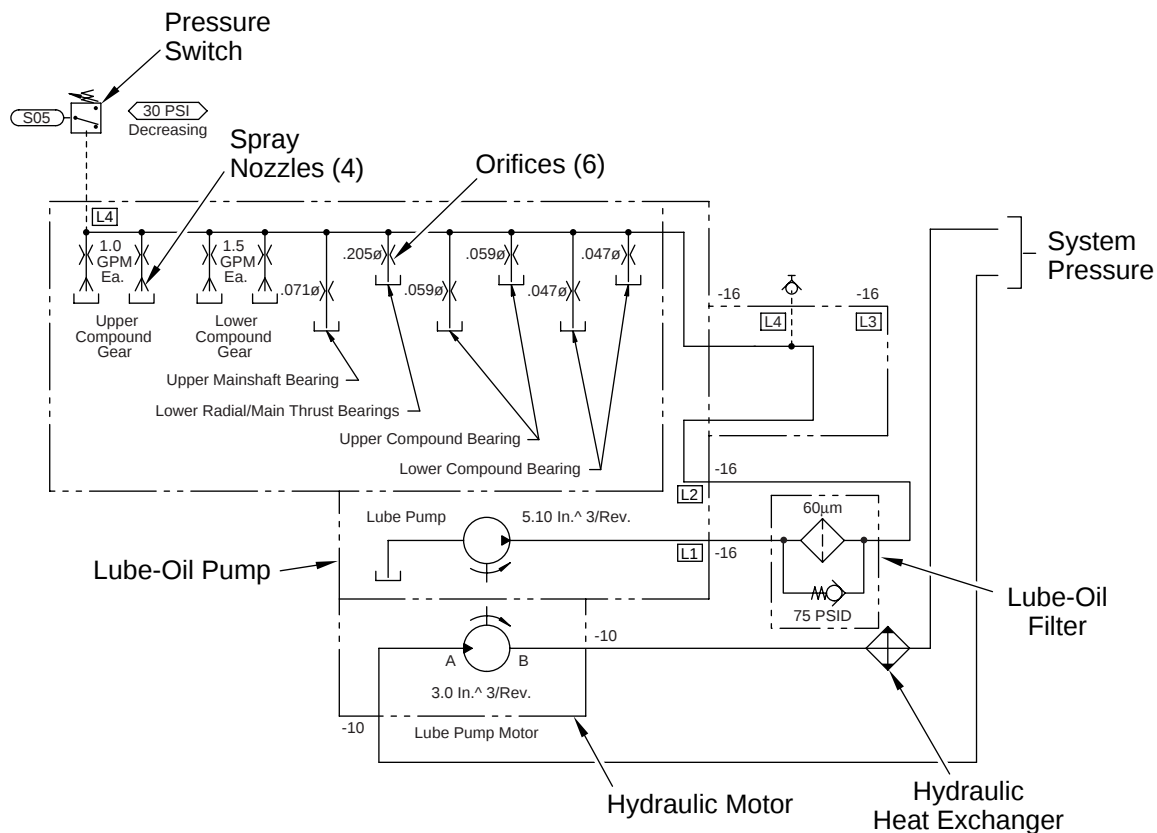
---

## Operation

Figure 4-35 shows the gearbox lubrication hydraulic system schematic. Hydraulic power drives the lubrication pump motor which drives a fixed displacement lube pump inside the gearbox housing. Test the hydraulic pressure to the lube pump motor at port PF. The pressure should not exceed 400 psi, and is limited by relief valve RV2. A heat exchanger lowers the temperature of the hydraulic fluid after it flows through the lube pump motor.

## System test

The lube pump delivers lube oil to the transmission gears and bearings. Lube oil pressure can be tested at port L4. Oil pressure is normally between 80 and 100 psi.



**Figure 4-35. Hydraulic circuit for the gearbox lubrication system**

**Table 4-14. Troubleshooting the gearbox lubrication and hydraulic system**

| <b>Problem</b>                             | <b>Probable cause</b>                            | <b>Remedy</b>                                             |
|--------------------------------------------|--------------------------------------------------|-----------------------------------------------------------|
| Oil leaking from lower seal.               | Worn oil seals.                                  | Replace seals.                                            |
| Oil leaking from upper bearing retainer.   | Worn oil seals.                                  | Replace seals.                                            |
| Gearbox oil temperature (less than 230°F). | Oil level too low or too high.                   | Adjust oil level to middle of sight glass.                |
|                                            | Incorrect lubricant used.                        | Check recommended lubricants chart and replace as needed. |
|                                            | Damaged gears or bearings.                       | Repair or replace as needed.                              |
| Oil pump loss alarm is on.                 | Oil level is too low.                            | Add oil.                                                  |
|                                            | Oil overheated.                                  |                                                           |
|                                            | Gear spray nozzle missing.                       | Replace spray nozzle.                                     |
|                                            | Excessive oil viscosity.                         | Lower oil viscosity.                                      |
|                                            | Faulty motor. Intermittent operation.            | Replace motor.                                            |
|                                            | Oil pump hydraulic motor failure.                | Replace motor.                                            |
|                                            | Broken lube pump adapter plate spline.           | Replace adapter plate spline.                             |
|                                            | Faulty fixed displacement pump.                  | Check pressure at PF. Replace pump if pressure is low.    |
|                                            | Low hydraulic fluid in reservoir.                | Add hydraulic fluid.                                      |
|                                            | Suction valve closed on fixed displacement pump. | Open suction valve.                                       |
| Water/mud in oil.                          | Missing inspection plugs.                        | Replace inspection plugs.                                 |
|                                            | Upper gearbox seals worn.                        | Replace seals.                                            |
| Excessive foaming.                         | Water in oil.                                    | Replace oil.                                              |
|                                            | Excessively viscous oil.                         | Lower oil viscosity.                                      |
|                                            | Cold oil.                                        |                                                           |
| Metal in oil.                              | Worn gears or damaged bearings.                  | Replace gears or bearings.                                |
|                                            | Damaged oil pump.                                | Replace oil pump.                                         |
| Restricted oil flow.                       | Foreign particles blocking orifice or nozzle.    | Clean orifice or nozzle.                                  |



March 9, 1998

# Chapter 7

## Disassembly and assembly

### Precautions

---



*Only authorized Varco repair technicians should perform the following major disassembly and assembly procedures.*



*Transport hydraulic components to a clean, dust-free service area before disassembling for service.*



Disassembly procedures are usually performed when replacing damaged components that are causing a tool function to fail. Whenever performing a disassembly, practice preventive maintenance by:

- ☐ Cleaning and inspecting all disassembled parts.
- ☐ Replacing all worn and damaged parts before they can cause another failure.
- ☐ Installing thread protectors on exposed threads.



*Torque all fasteners to the limits given in DS00008 (Design Specification Design Torque Standard), unless an alternative torque value is given in the procedure.*

## PH-50 Pipehandler

---

### Disassembling the PH-50 Pipehandler

Remove the PH-50 Pipehandler to service the following components:

- ☐ Load stem
- ☐ Load stem seals
- ☐ Rotating link adapter upper and lower bearings
- ☐ Rotating link adapter thrust bearing
- ☐ Rotating link adapter rotary seals



***Release all hydraulic oil pressure before disconnecting hydraulic lines. Hydraulic oil under pressure can penetrate skin and cause serious injury.***



***Before opening the hydraulic system, thoroughly clean the work area, and maintain system cleanliness by promptly capping all disconnected lines. Dirt is extremely harmful to hydraulic system components and can cause equipment failure and subsequent injury to personnel.***



To protect the rotating link adapter seals and inner surfaces, remove the load stem along with the rotating link adapter.



Contact the nearest Varco Service Center for details about building an appropriate stand for removing the rotating link adapter.

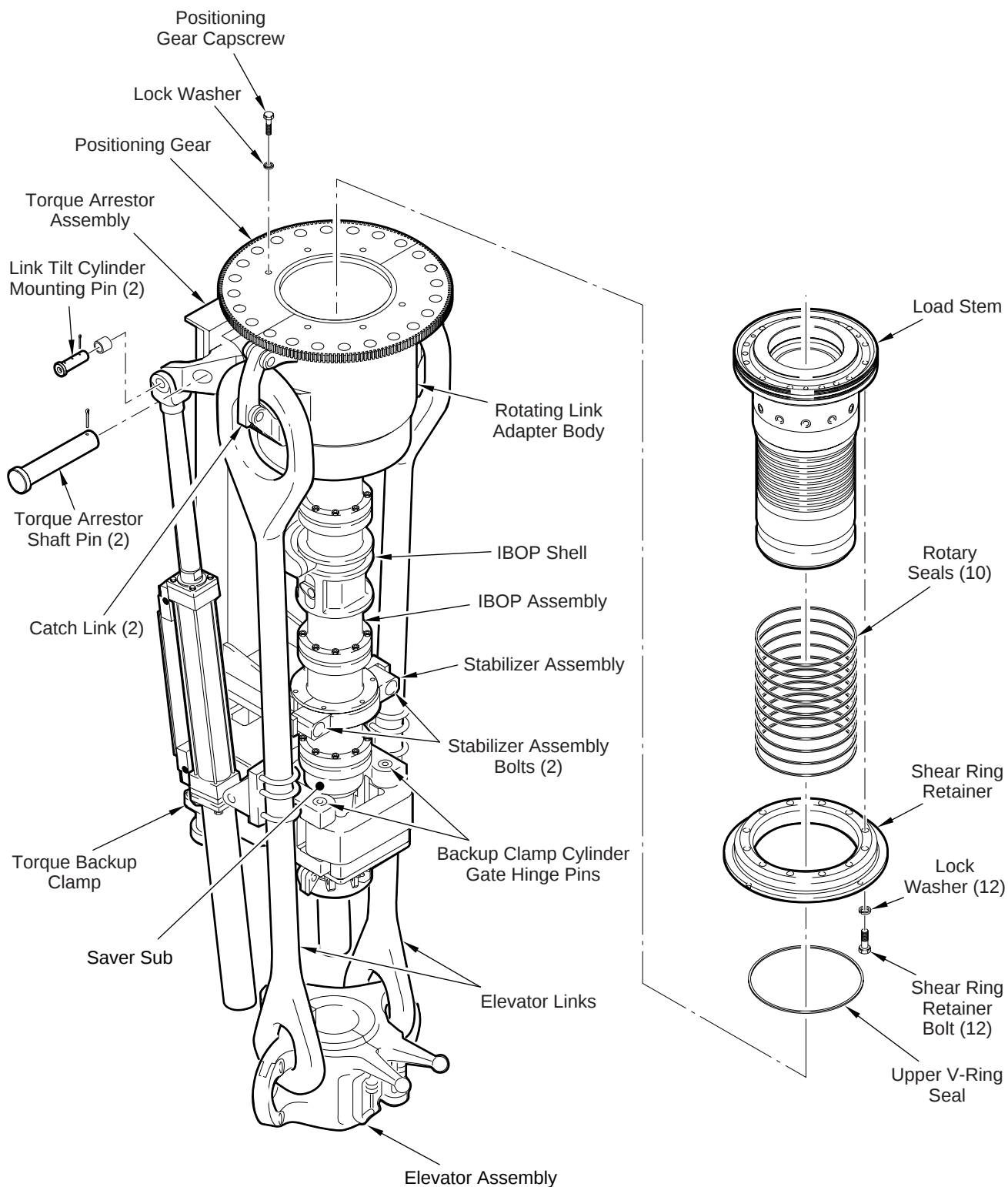
Refer to Figure 4-36 when performing the following pipehandler disassembly procedures:

1. Disengage the shot pin.
2. Disconnect the hydraulic lines and cap all connections.
3. Remove one of the backup clamp cylinder gate hinge pins and open the gate.
4. Remove the two bolts (with slotted nuts and cotter pins) that hold the stabilizer assembly halves together.
5. Remove the two pins that attach the link tilt brackets to the actuators, and remove the drill pipe elevator and links.



The link tilt brackets remain attached to the links.

6. Remove the two pins that attach the link tilt actuators to the rotating link adapter and remove the two link tilt actuators.
7. Remove the pin attaching the torque arrestor to the rotating link adapter and remove the torque arrestor and link tilt cylinders.
8. Remove the upper IBOP crank assembly.
9. Remove the lower tool joint lock.
10. Remove the intermediate joint lock.
11. Remove the IBOP actuator shell.
12. Remove the upper tool joint lock.
13. Remove the saver sub, lower IBOP, and upper IBOP.
14. Rotate the positioning gear until one half of the gear is clear of the shot pin bracket slot.
15. Remove the lockwired capscrews that hold the one half of the positioning gear and remove the gear half.
16. Rotate the positioning gear until the remaining half of the gear is clear of the shot pin bracket slot.
17. Remove the lockwired capscrews that hold the remaining half of the positioning gear and remove the gear half.



**Figure 4-36. PH-50 Pipehandler assembly/disassembly**

18. Remove the 12 lockwired capscrews and lockwashers holding the shear ring retainer in place in the motor housing assembly. Mark the load stem to assure proper orientation when reassembling.
19. Lower the TDS until the bottom of the rotating link adapter just rests on the stand. Remove the six pipe plugs in the flange of the load stem and install three 5/8-11 UNC bolts into the jacking holes to hold the load stem to the main body. Continue to lower the TDS, tightening the three bolts as the TDS is lowered.



***Support the rotating link adapter before removing the three-piece shear ring and raising the main body. The rotating link adapter weighs approximately 2,200 pounds.***

20. Remove the three-piece main body shear ring.
21. Remove the three bolts and carefully raise the main body until the rotating link adapter/load stem are clear.

## Assembling the PH-50 Pipehandler

Refer to Figure 4-36 when performing the following pipehandler assembly procedures:

1. Install the new main shaft seals inside the load stem bore—one seal lip facing up and one seal lip facing down.



***Always install new main shaft seals and use care not to damage seal lips or case.***

2. Install the new O-rings on the load stem flange.
3. Grease the walls of the bore in the main body, the load stem main shaft seals, and the O-rings.
4. Carefully install the load stem into the main body, making sure that the load stem side ports are properly oriented.

5. Using three 5/8-11 UNC bolts, pull the load stem to the main body and completely seat the load stem into the bore.
6. Install the three main body shear rings.
7. Remove the bolts holding the load stem inside of the main body and install pipe plugs into all the threaded ports on the load stem flange.
8. Install the three piece shear ring retainer with the 12 capscrews and lockwashers. Tighten the capscrews to 250-270 ft lb and safety wire the capscrews with .051 in. diameter lockwire.
9. Install the two halves of the positioning gear and tighten the capscrews to 250-270 ft lb and safety wire the capscrews.
10. Install the upper IBOP, lower IBOP, and saver sub. Tighten each to the torque specified in DS00008.
11. Install the upper tool joint lock and tighten the bolts to 180-190 ft lb.
12. Install the IBOP actuator shell.
13. Install the intermediate tool joint lock and tighten the bolts to 180-190 ft lb.
14. Install the lower tool joint lock.
15. Install the upper IBOP crank assembly.
16. Pin the torque arrestor to the rotating link adapter.



The clamp assembly remains attached to the torque arrestor.

17. Pin the two link tilt actuators to the rotating link adapter.
18. Position the drill pipe elevator and links, and pin the link tilt brackets to the link tilt actuators.
19. Attach the two halves of the stabilizer assembly with bolts, slotted nuts, and cotter pins.
20. Close and pin the backup clamp gate.
21. Connect all hydraulic lines.

# Rotating link adapter/load stem

---

## Disassembling the rotating link adapter/load stem

Refer to Figure 4-37 when performing the following rotating link adapter disassembly procedures:

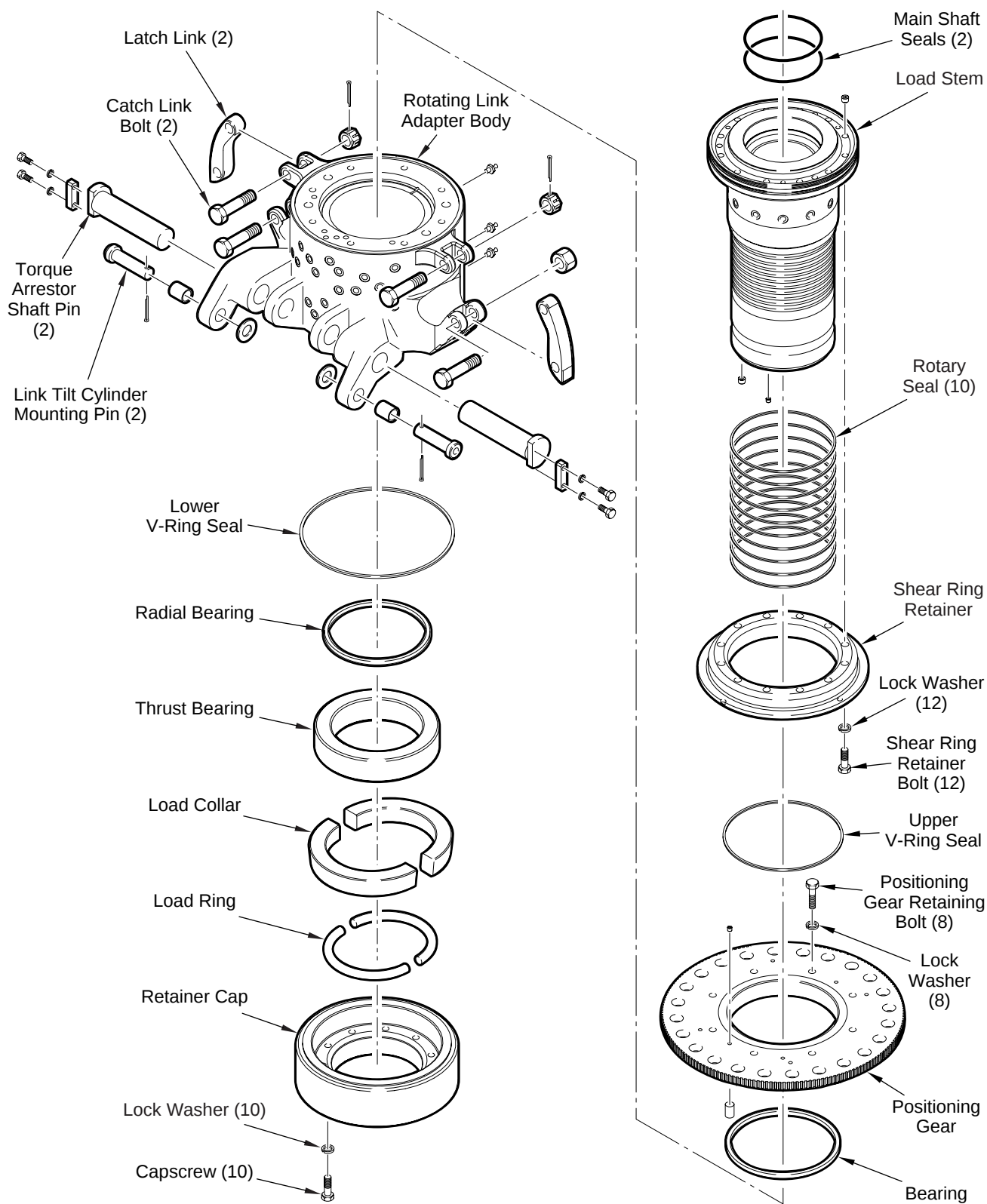
1. Remove the pipehandler as described above and transport the rotating link adapter/load stem to a suitable work area.
2. Orient the rotating link adapter/load stem so that the load stem flange (top of stem) is down on a suitably protected surface.
3. Remove the capscrews that hold the retainer cap, collar, and split load ring in place.
4. Remove the retainer cap, collar, and split load ring.
5. Remove the V-ring wiper seal and discard.
6. Lift the rotating link adapter by the link ears and separate the rotating link adapter from the load stem. Set the rotating link adapter on a suitably protected surface.



*Protect the internal surfaces of the rotating link adapter and the surfaces of the load stem when separating the two components. When removing the rotating link adapter from the load stem, carefully tap with a mallet to remove the rotating link adapter from the load stem. There can be resistance from the press-fitted upper and lower rotating link adapter bearings.*

7. Remove the thrust bearing and lower radial bearing from the rotating link adapter.
8. Remove the upper radial bearing from the load stem.
9. Remove the V-ring wiper seal and discard.
10. Remove the load stem retainer plate.
11. Remove the eight rotary seals and discard.
12. Invert the load stem. Remove and discard the load stem flange O-rings and load stem bore shaft seals.



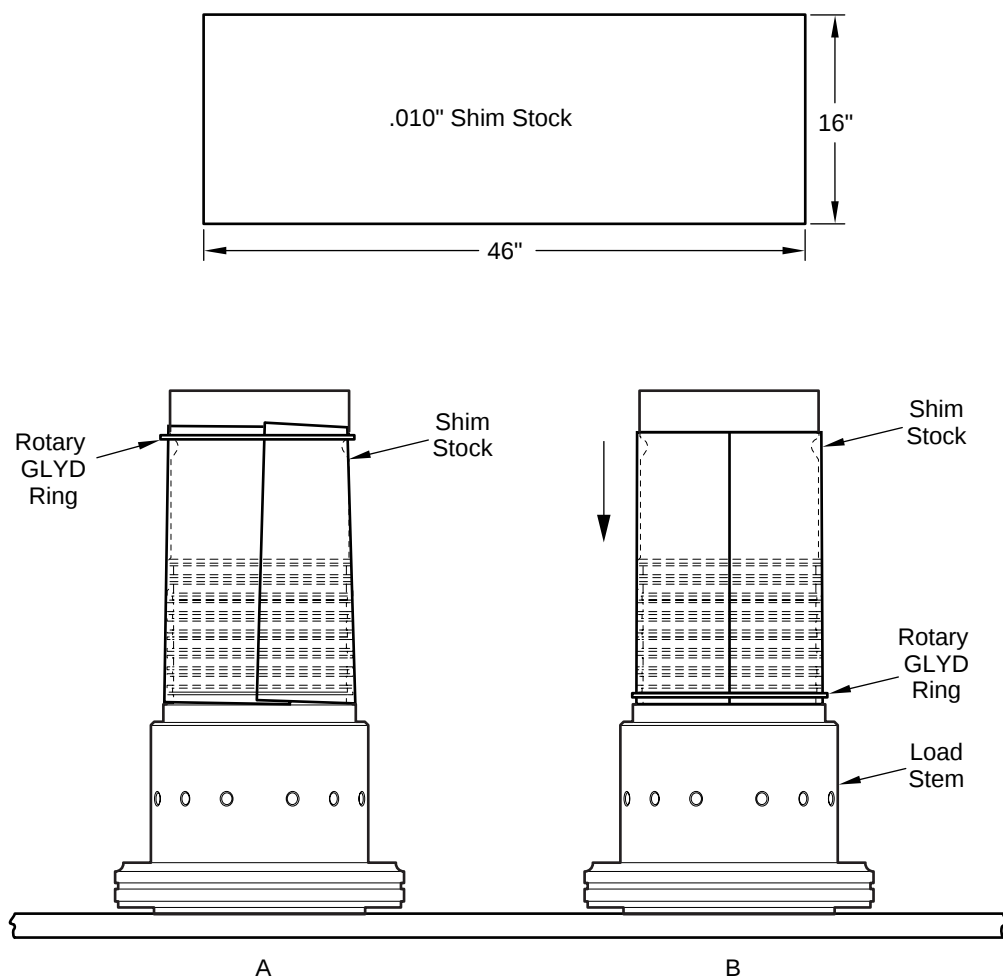


**Figure 4-37. Rotating link adapter assembly/disassembly**

## **Assembling the rotating link adapter/load stem**

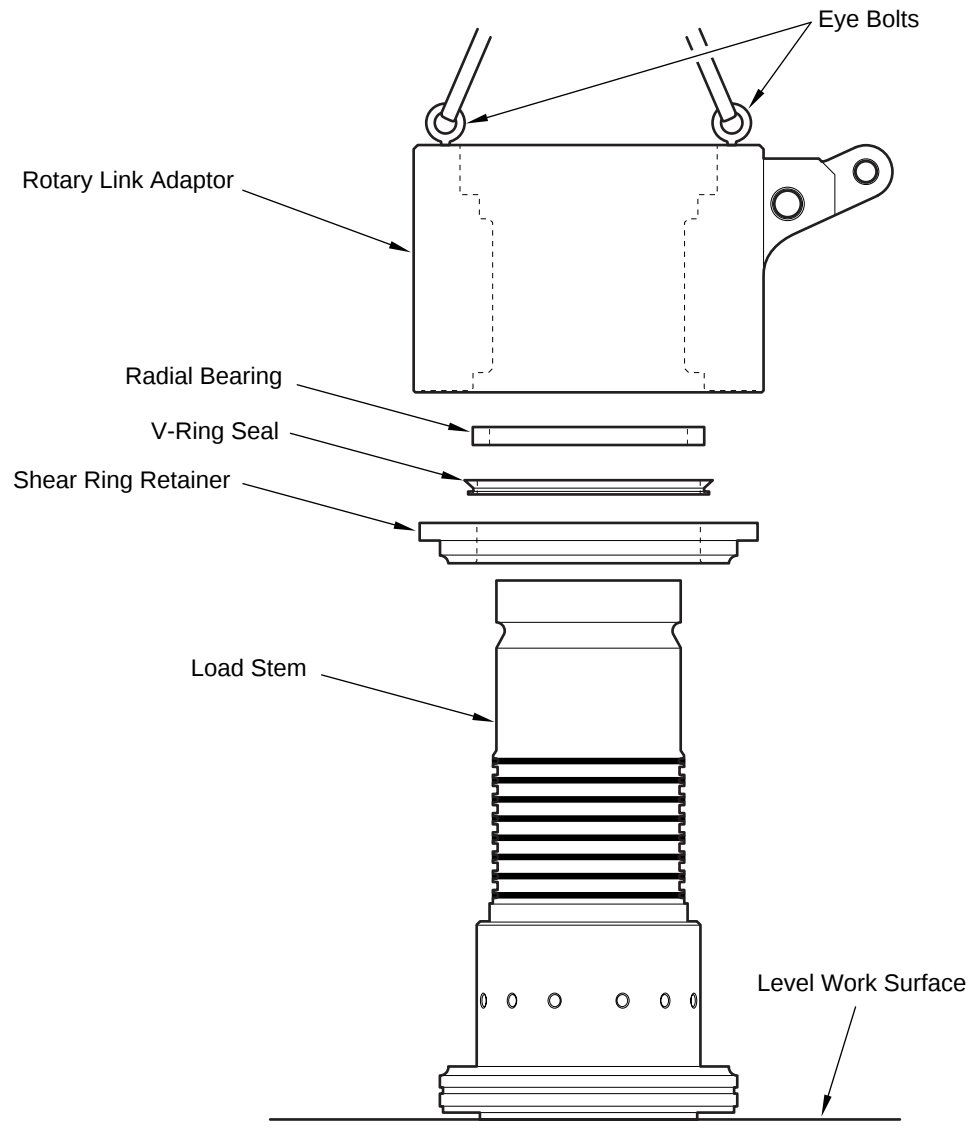
Refer to Figure 4-37 when performing the following procedure:

1. Orient the load stem so the load stem flange (top of stem) is down on a suitably protected surface.
2. Install the load stem retainer plate, making sure the retaining ring grooves face the load stem flange.
3. Install a new V-ring seal so that the lip faces up.
4. Install the upper radial bearing onto the load stem. Tap the bearing in place using a brass rod and hammer, as required.
5. Place the load stem on a flat surface and wrap .010 in. shim stock, in the shape of a cone, over the straight ungrooved part of the load stem (Figure 4-38).
6. Lubricate one of the rotary seals with hydraulic fluid and slip it over the small end of the shim stock cone.
7. Straighten the shim stock cone into a cylinder and slide the cylinder to the top of the lowest groove (groove that is closest to the load stem flange).
8. Slide the seal down to the cylinder and into the groove. Take care not to let the seal twist in the groove. A light coating of oil may facilitate this procedure.
9. Go back to step 5 and repeat the procedure for remaining rotary seals.
10. Support the load stem on a flat surface.



**Figure 4-38. Installing the rotary seals**

11. Hang the rotating link adapter and line up the bore with the load stem (Figure 4-39).
12. Lubricate the bore of the rotating link adapter with hydraulic oil.



**Figure 4-39. Assembling the rotating link adapter/load stem**

13. Carefully begin lowering the rotating link adapter over the load stem. When the first rotary seal reaches the top of the chamfer in the rotating link adapter bore, stop lowering the link adapter. Examine the first seal and make sure that the seal is well inside its groove. Continue cautiously lowering the link adapter. If any part of the seal hags up on the edge of the bore, stop lowering, raise up the link adapter slightly, then lower again slowly while feeding the binding part of the seal into the bore with a straightedge.
14. Install the lower link adapter radial bearing using a brass rod and hammer into place, as required.
15. Install the rotating link adapter thrust bearing.
16. Install the new V-ring seal onto the rotating link adapter with the lip facing the link adapter.
17. Install the collar, split load ring, and retainer cap. Apply anti-seize compound to the capscrews and tighten the capscrews in a star pattern to 250-270 ft lb. Safety wire the capscrews with .051 in. diameter lockwire.
18. Invert the rotating link adapter/load stem so that the load stem flange is up.
19. Install two new main shaft seals inside the load stem bore with the first installed seal lip facing down and the second installed seal lip facing up.



Lips of the seals should face away from each other, not towards each other. Apply a heavy coating of grease between the seals.



*Always install new mainshaft seals and use care not to damage the seals or the case.*

20. Install two new load stem flange O-rings.



A light coating of grease applied to the O-rings will help in installing the rotating link adapter/load stem into the TDS main body.



*Always install new load stem O-rings and use care not to damage the O-rings or the case.*

# Transmission/motor housing

---

## Removing the transmission/motor housing

Remove the transmission/motor housing to service the following components:

- ☐ Compound gear sets and bearings
- ☐ Main shaft
- ☐ Main thrust bearing
- ☐ Bull gear

The AC drive motors and the hydraulic oil reservoir can be removed with the TDS-9S left in place. To remove these components, skip to the applicable removal section below.

To remove the transmission/motor housing:

1. Remove the PH-50 pipehandler components as described above.
2. Remove the saver sub and the lower and upper IBOPs.
3. Disconnect the service loop, rig down the tool, and transport the transmission/motor housing to a suitable work area. See the *Installation and Commissioning* for rig down procedures.

## Installing the transmission/motor housing

Perform the rig up procedures in the *Installation and Commissioning* book.

## Disassembling the transmission/ motor housing

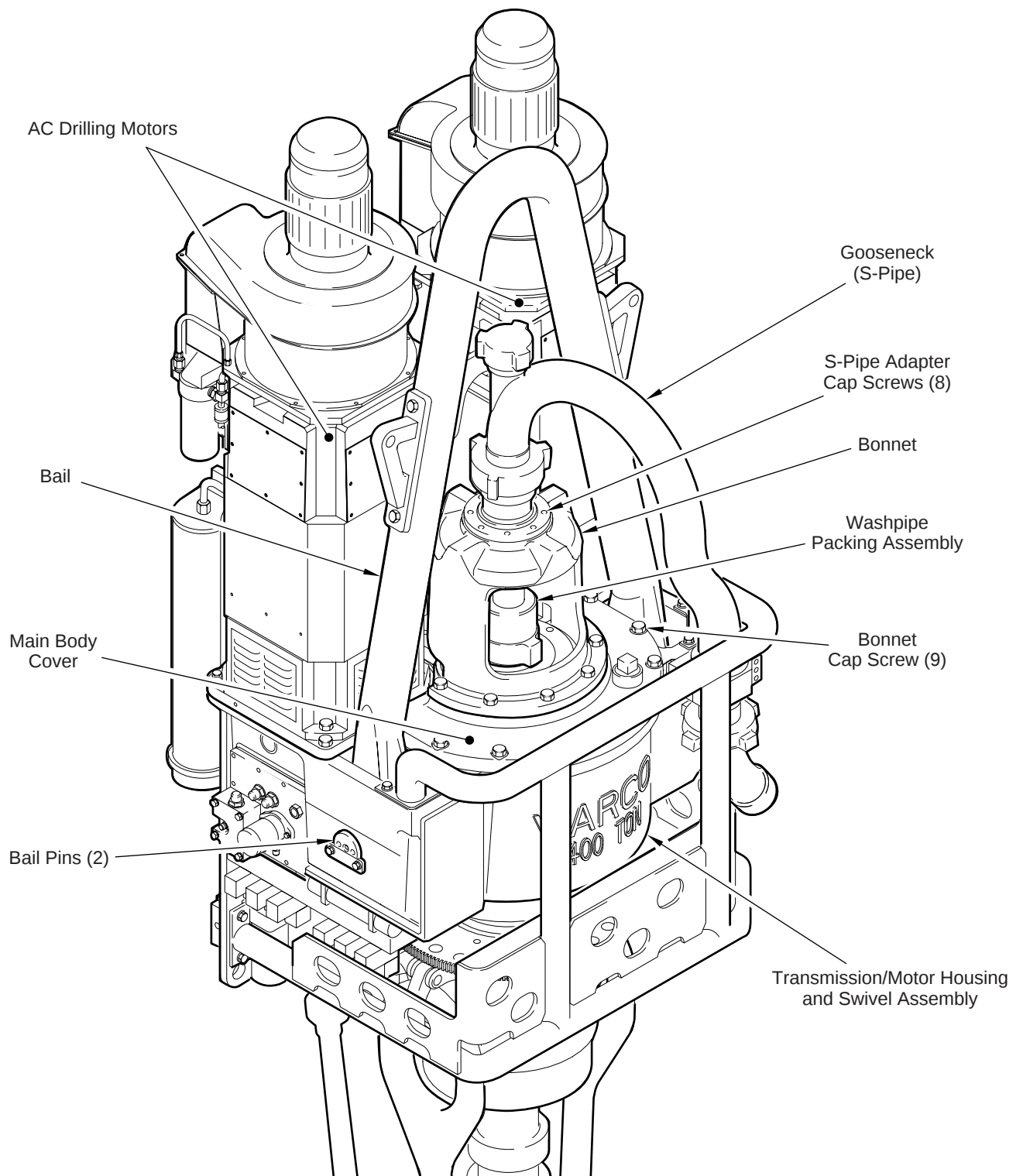


Drain the oil from the transmission/motor housing and the hydraulic oil reservoir before disassembling components.

### Removing the bonnet and wash pipe

Refer to Figure 4-40 when performing the following transmission/motor housing assembly upper component disassembly procedures:

1. Remove bail pins and bail.
2. Remove the S-pipe and the wash pipe packing.
3. Remove the eight capscrews and lockwashers that hold the S-pipe adapter in place and remove the adapter.
4. Remove the nine lockwired capscrews and lockwashers that attach the bonnet to the main body cover and remove the bonnet.
5. Remove the upper stem liner on top of the main shaft using the two pry points, and remove and discard the liner seal.
6. Remove the bearing shield from the top of the main shaft.



**Figure 4-40. Transmission/motor housing upper components assembly**



## Removing the upper bearing retainer plate

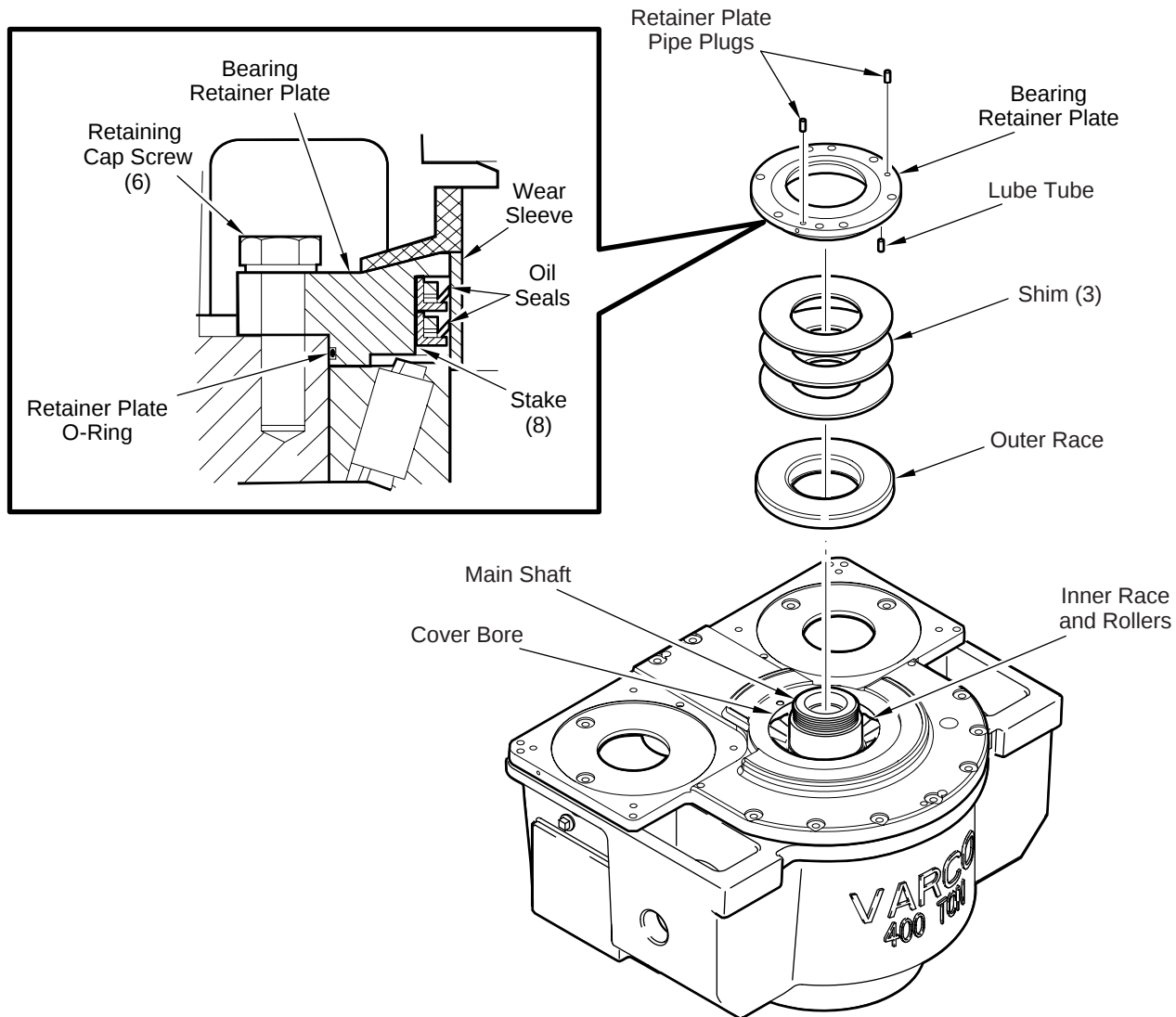
Refer to Figure 4-41 when removing the upper bearing retainer plate as follows:

1. Remove the six capscrews and lockwashers that attach the bearing retainer plate to the main body cover and remove the plate.



Use the two jacking holes in the upper bearing retainer plate as required to help remove the plate.

2. Remove the lube tube from the lube tube bore of the cover, and remove the lube tube O-rings.
3. Remove and discard the two lip seals in the bearing retainer plate.
4. Remove the bearing retainer plate shims.
5. Cool the taper roller bearing outer race to at least 0°F, but no more than -60°F, and remove it.



**Figure 4-41. Removing the upper bearing retainer plate**

## Removing the AC drilling motors and hydraulic oil reservoir

1. Remove the four capscrews that hold the reservoir mounting bracket in place and remove the bracket and reservoir.
2. One motor at a time, remove the four capscrews and lockwashers that hold each AC drilling motor to the main body. Remove each motor separately by attaching handling gear to the brake end of the motor and lifting each motor off the main body cover.
3. Remove the O-rings that seal the AC drilling motor to the main body.

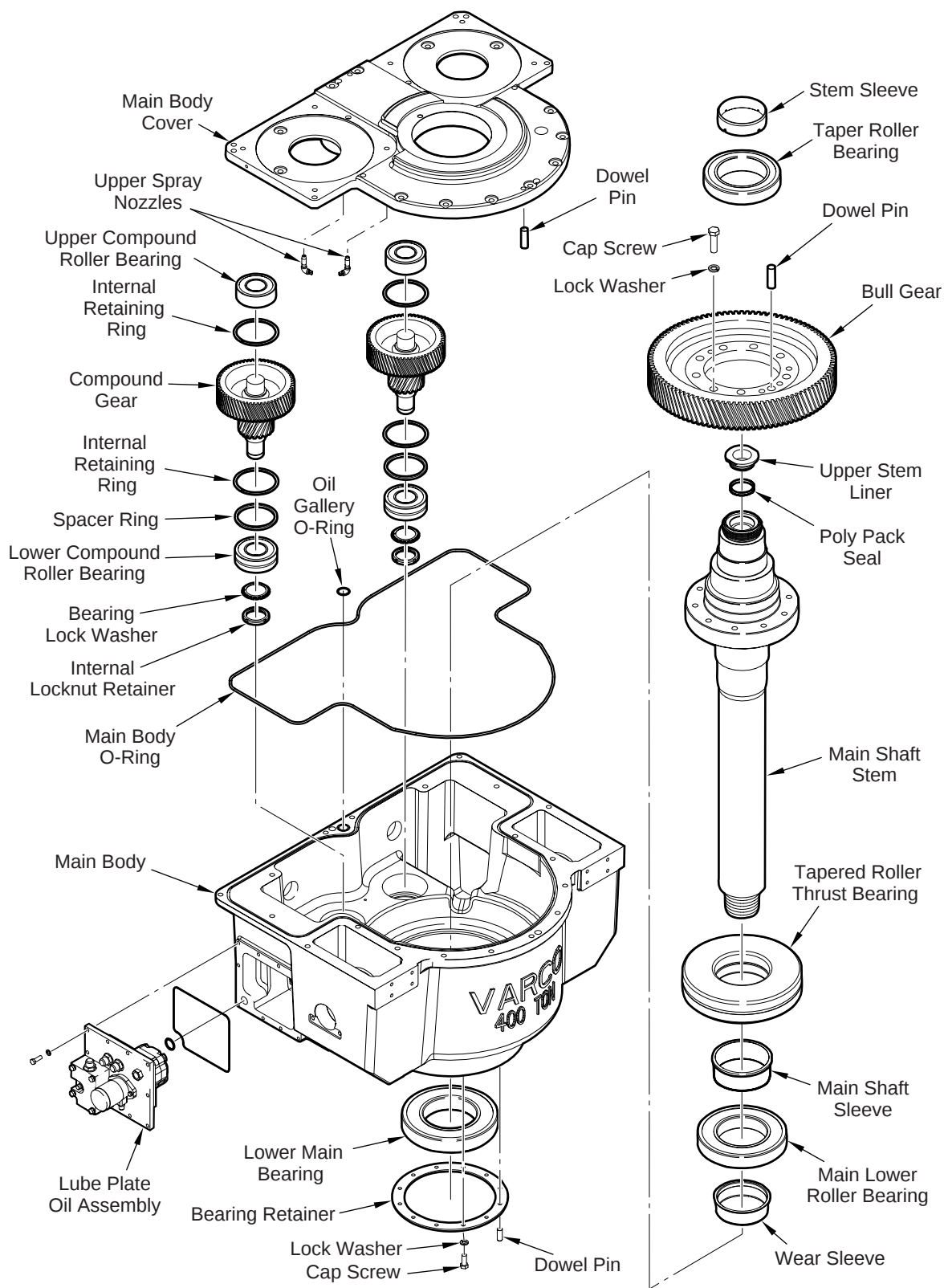
## Removing transmission components



*Facilitate bearing removal by heating bearings with an induction heater. Because this method heats quickly, and could possibly damage bearings, always use a Tempilstik or pyrometer to monitor bearing temperature.*

Refer to Figure 4-42 when performing the following transmission/motor housing disassembly procedures:

1. Remove the 19 cover capscrews that attach the cover to the main body and remove the cover by lifting it straight off of the main body.
2. Inspect the main body flange dowel pins, and remove and discard the pins if damaged.
3. Remove the main body O-ring and the oil gallery O-ring.
4. Remove the two upper spray nozzles.
5. Remove the internal retaining rings that hold the upper compound roller bearings in place, and remove the bearings.
6. Remove and inspect the main body orifices and the pipe plugs.
7. Remove the inner race of the upper compound roller bearing by heating to between 200-250°F (90-120°C) and pulling the races off of the compound gear shaft.
8. Remove the main body lower bearing covers.



**Figure 4-42. Transmission/motor housing assembly and disassembly**

9. Remove the lock washer and bearing nut on the bottom of each compound gear.
10. Press the compound gear from the bore of the compound gear lower bearing using a 50-ton hydraulic jack.



Light heating of the lower compound roller bearing helps when removing the gear from the bearing, but do not exceed 200°F (90°C).



*Do not use a steel hammer when removing the gears-it can damage components.*

11. Remove the internal retaining rings from the top of the lower compound roller bearing spacer rings.
12. Remove the spacer rings from the bore on the top of the lower compound roller bearings.
13. Remove the lower compound roller bearings from the bore in the housing.
14. Remove the two lower spray nozzles.
15. Remove the stem sleeve by heating the sleeve to 250°F (120°C). Check the sleeve for wear after removing it.
16. Remove and discard the upper taper roller bearing inner race by heating the race to 250°F (120°C).



If replacing the bull gear, perform steps 14, 15, and 16. If not, proceed to step 17 and remove the bull gear along with the main shaft.

17. Remove the 10 lockwired capscrews that hold the bull gear in place.
18. Install two 5/8-11 UNC forged eyebolts in the bull gear pickup holes and heat the bull gear to between 150-200°F (65-90°C), then remove the bull gear by lifting the gear straight up off the alignment pin.

19. Inspect the bull gear alignment dowel pin, and remove and discard the pin if damaged.
20. Remove the main shaft from the main body.
21. Remove the main shaft wear sleeve by heating the sleeve to 250°F (120°C), then pulling the sleeve off of the shaft. Check the sleeve for wear grooves after it is removed.
22. Remove the main lower roller bearing inner race by heating the race to 250°F (120°C), then pulling the race off the main shaft.
23. Restrain the main shaft in a vertical position with the bottom facing up.
24. Remove the main shaft sleeve by heating the sleeve to between 200-250°F (90-120°C) and pulling the sleeve off the shaft.
25. Remove half of the tapered roller thrust bearing race, the bearings, and the cage of the thrust bearing.
26. Remove the other half of the thrust bearing race by heating the race to 200°F (90°C) and pulling the race off the main shaft.
27. Turn the main body over.
28. Remove the twelve lockwired capscrews that hold the lower main bearing retainer in place and remove the retainer.
29. Remove the outer race of the lower main bearing from the bore in the housing with a bearing puller.

## Assembling the transmission/motor housing



*Keep the transmission bearings, shafts, and housing free of chips, burrs, and dirt during the following assembly process to prevent damage to transmission parts.*



Varco strongly recommends replacing any bearing or gear when even the slightest wear is indicated. It is usually less expensive to replace any questionable parts found during disassembly than risk having to rebuilt the gearbox later.

## Assembling the main body

Use the following procedures to assemble the main body:

1. Steam clean the main body, blowing out all passages (make sure all the plugs and spray nozzles are removed). Apply a protective coating, such as WD-40, to all unpainted internal surfaces.
2. Install the three main body pipe plugs using a 9 in. Allen wrench (Figure 4-43).

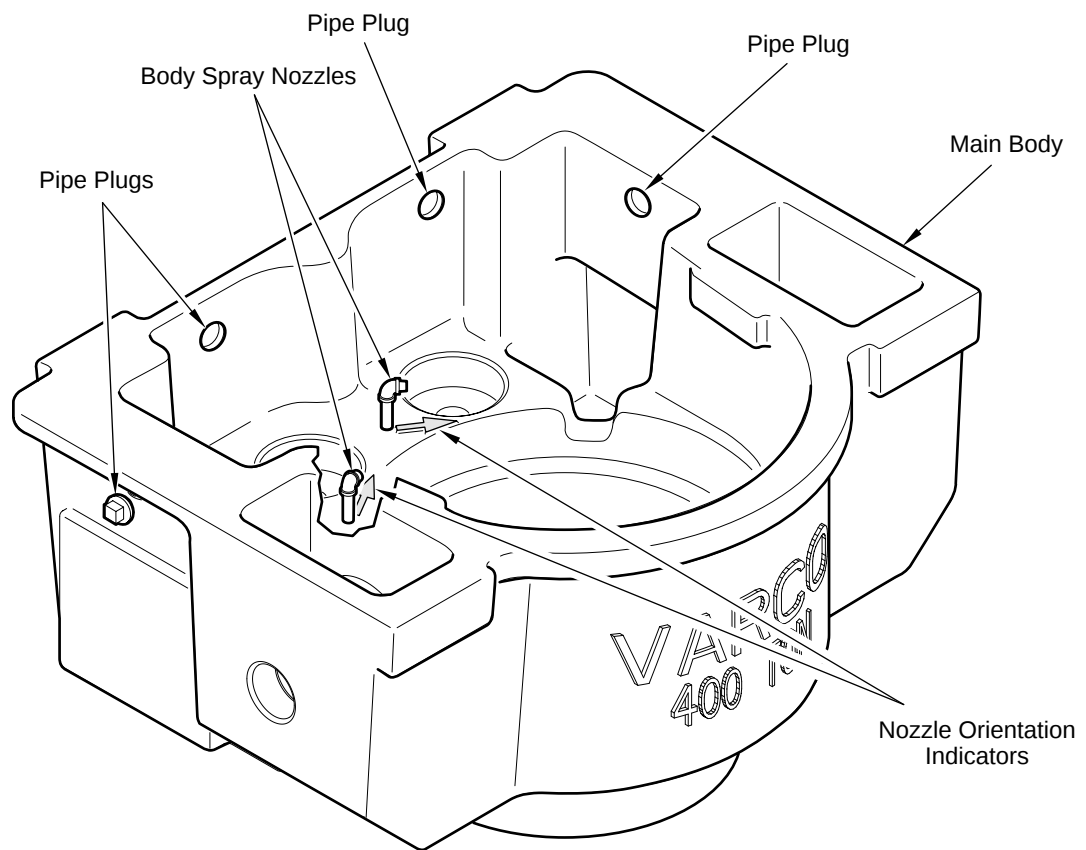


Do not apply any thread sealant to the orifice.

3. Apply thread sealant (not Teflon tape) to the six pipe plugs and install them in the oil gallery openings.
4. Chill the outer race of the lower main bearing to at least 0°F (-18°C), but no lower than -60°F (-51°C), then install the bearing into the bore of the housing. Immediately after installing the bearing, spray the bearing with WD-40 to prevent corrosion.



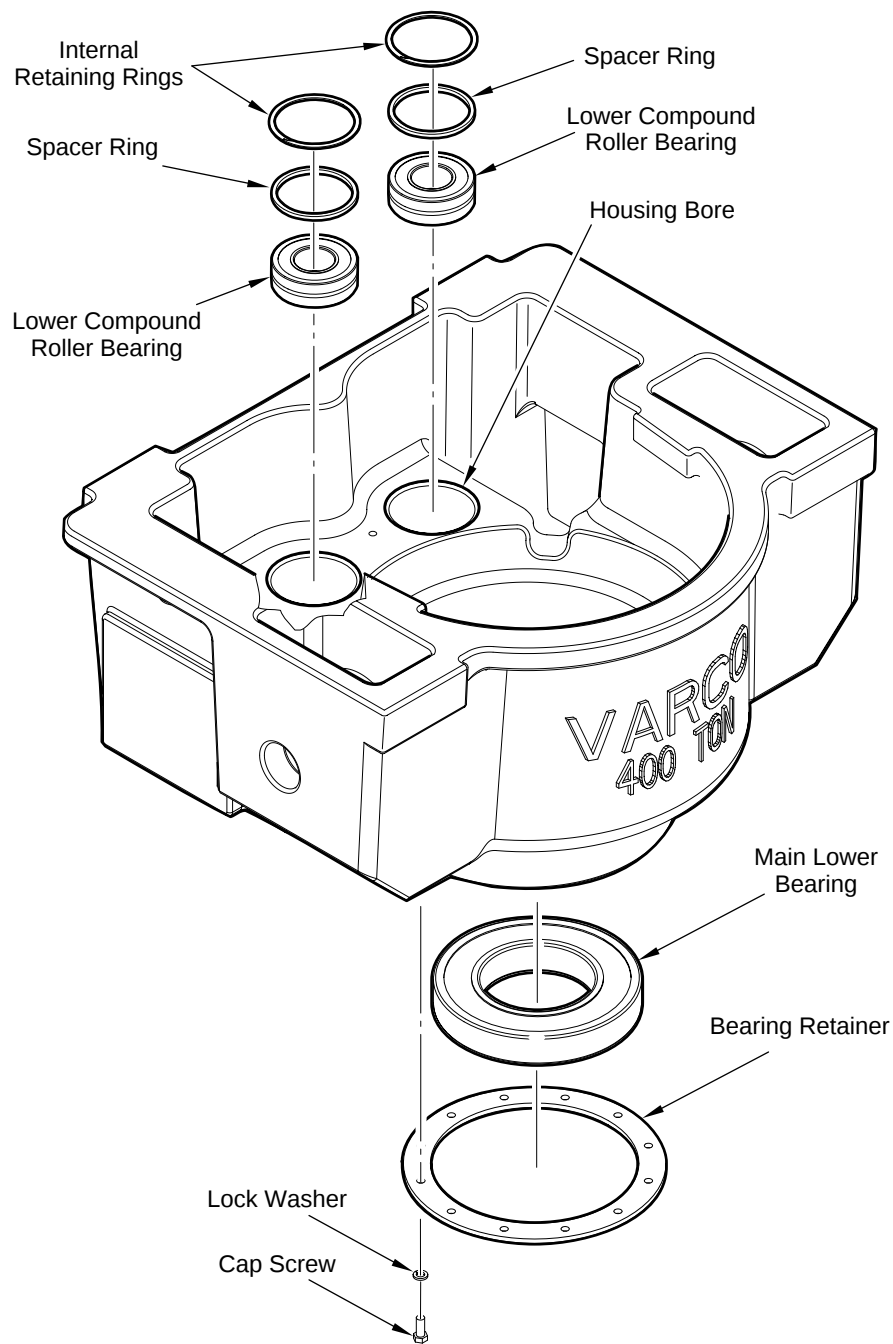
*Do not use liquid nitrogen to cool parts. Temperatures below -60°F (-50°C) can affect the composition of certain metals and lead to the weakening of parts.*



**Figure 4-43. Assembling the transmission/motor housing**



5. Install the lower radial bearing retainer, making sure the three alignment holes in the retainer match the alignment holes in the body (Figure 4-44).
6. Apply an anti-seize compound to the threads of the twelve 1/2 in. hex head capscrews that hold the bearing ring retainer in place, and install the capscrews and lockwashers in place. Tighten the capscrews in a star pattern to 71-79 ft lb.
7. Safety wire the capscrews with .047 in. diameter lockwire.
8. Turn the main body over.
9. Cool the lower compound roller bearings to at least 0°F (-18°C), but no lower than -60°F (-51°C), then install the bearings into the bore of the housing. Immediately after installing the bearing, spray them with WD-40 to prevent corrosion (Figure 4-44).
10. Install the spacer rings into the bore on top of the lower bearings (Figure 4-44).
11. Install the internal retaining rings on top of the spacer rings.

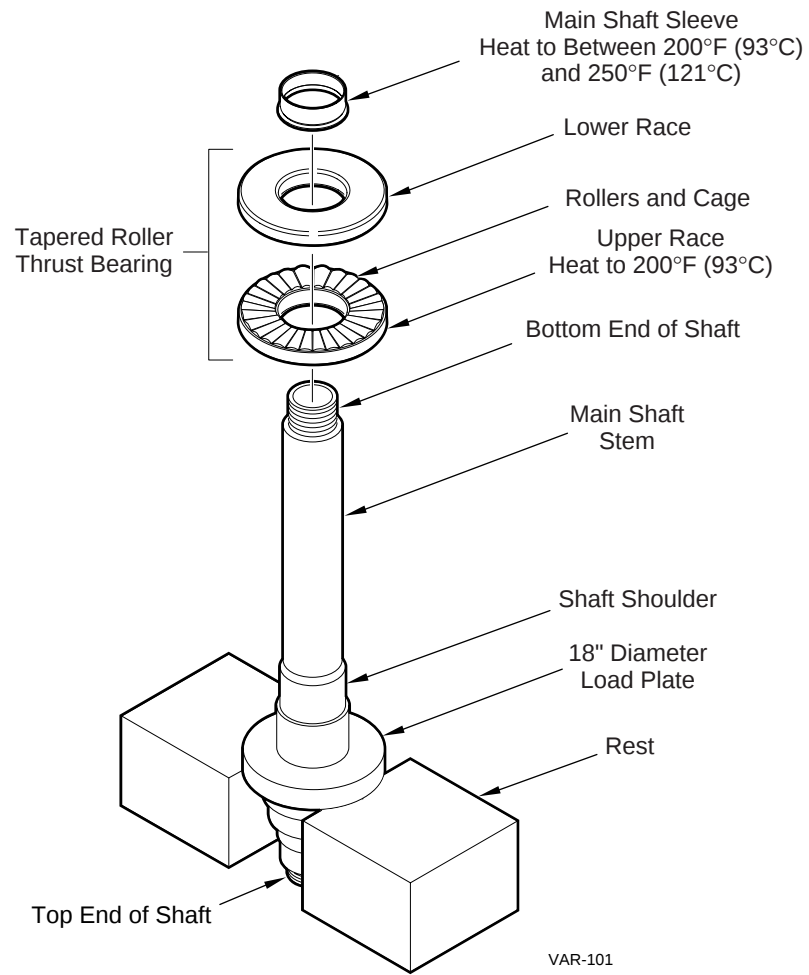


**Figure 4-44. Assembling the transmission/motor housing**

## **Assembling the main shaft**

Refer to Figure 4-45 when performing the following procedure:

1. Remove any burrs, steam clean, and coat the main shaft with a protective coating such as WD-40.
2. Restrain the main shaft in a vertical position with the bottom facing up.
3. Heat the upper race of the tapered roller thrust bearing to 200°F (90°C) and install the race on top of the 18 in. diameter load plate machined into the shaft. Rotate the race until it seats flat on the plate.
4. Install the tapered roller thrust bearing's roller bearings and cage and apply clean grease to the bearing rollers.
5. Install the other half of the tapered roller thrust bearing race.
6. Heat the main shaft sleeve to 200-250°F (90-120°C) and install the sleeve on the shaft shoulder by rotating the sleeve until it seats on the shoulder.
7. Heat the lower main bearing inner race to 225°F-250°F (110-120°C) and install the race onto the main shaft sleeve by rotating the race until it seats.
8. Inspect the wear sleeve. If the sleeve shows signs of wear or damage, replace it.
9. Heat the wear sleeve to 250°F (120°C) and install the sleeve.



**Figure 4-45. Assembling the transmission/motor housing**

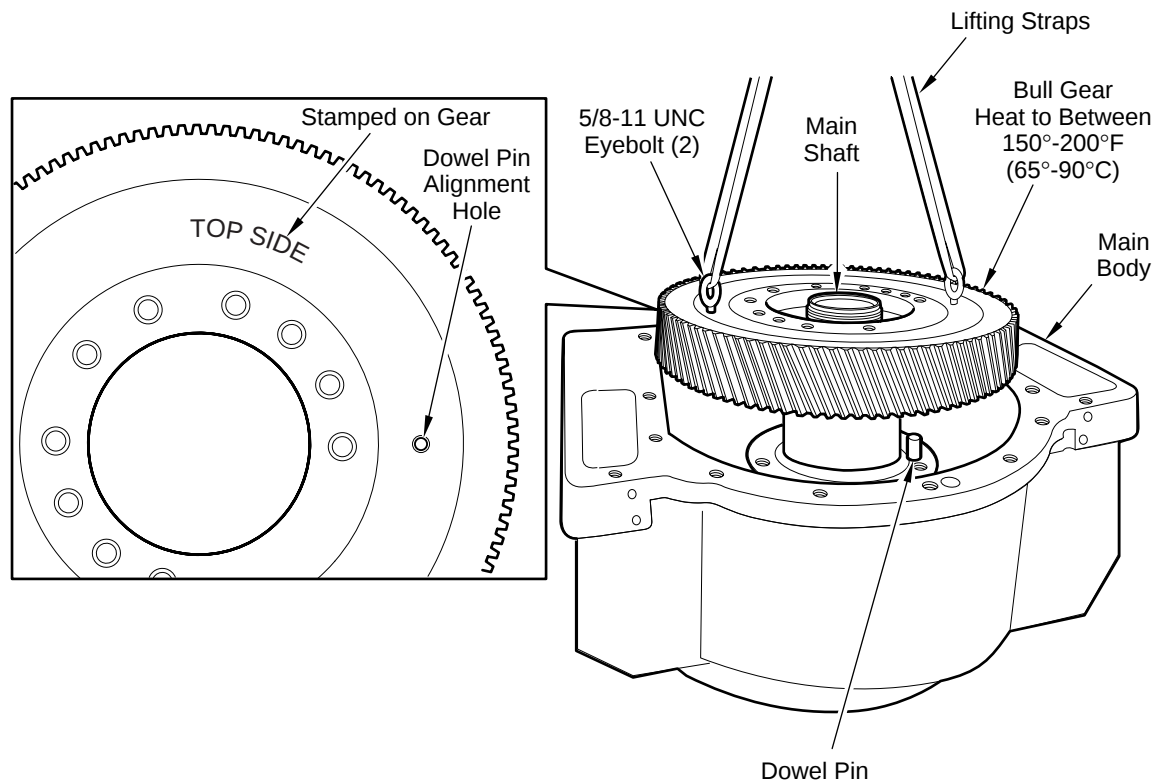
## Assembling the gears to the main body

1. Apply grease to the rollers of the lower main bearing.
2. Invert the main shaft and install it into the main body (Figure 4-46).
3. Heat the bull gear to 150-200°F (65-90°C). Install two 5/8-11 UNC forged eyebolts in the gear pickup holes, making sure the stamping TOP SIDE is up.
4. Carefully lower the bull gear into position until it seats. If the old dowel pins have been removed, rotate the gear until the 1 1/4 in. dowel pin holes are aligned.



If the bull gear dowel pins have been removed, chill the new dowel pins to at least 0°F (-18°C), but no lower than -60°F (-51°C) as the bull gear is being placed into position. Then drive the dowel pins into the alignment holes using a bronze hammer. The pins will sit flush to 1/4 in. high.

5. Apply an anti-seize compound to the threads of the ten 1 in. hex head capscrews that hold the bull gear in place, and install the capscrews and lockwashers in place. Tighten the capscrews in a star pattern to 610-670 ft lb.
6. Safety wire the capscrews with .051 in. diameter lockwire.
7. Heat the upper taper bearing inner race to 225-250°F (110-120°C). Install the bearing rotating the race until it seats.
8. Inspect the upper wear sleeve. If the sleeve shows signs of wear or damage, replace it.
9. Heat the upper wear sleeve to between 200-250°F (90-120°C). Install the sleeve and rotate the sleeve until it seats (Figure 4-43).
10. Apply Loctite® 242 Threadlocker (Blue) to the two lower spray nozzles and install them into position. Make sure the slits in the face are vertical.
11. Chill the compound gears to at least 0°F (-18°C), but no lower than -60°F (-51°C). Install the gears into the bores of the lower compound roller bearings. Immediately after installing the gears, spray them with WD-40 to prevent corrosion.



**Figure 4-46. Assembling transmission/motor housing**



Light heating of the lower compound roller bearing aids in fitting the gear to the bearing, but do not exceed 200°F (90°C). Use a bronze hammer to tap the gears into place.



*Do not use a steel hammer when installing gears - it can damage components.*

12. Install a new bearing lock washer and reuse the old internal locknut retainer on the bottom of each compound gear. Tighten to 200-250 ft lb. Bend the lockwasher tabs to secure the nuts.
13. Heat the inner race of the upper compound roller bearing to 225-250°F (110-120°C). Install and rotate the race until it seats.

## Assembling the cover

1. Steam clean the inside of the main body cover, making sure the plugs and spray nozzles are removed. Coat the inside of the cover with a protective coating, such as WD-40.
2. Install the two orifices with an Allen wrench.
3. Apply thread sealer (not Teflon tape) to the threads of the three oil gallery pipe plugs and install them.
4. Chill the compound gear upper bearings to at least 0°F (-18°C), but no lower than -60°F (-51°C). Install the bearings into the bores in the housing cover. Immediately after installing the bearings, spray the bearings with WD-40 to prevent corrosion.
5. Install the internal retaining rings that hold the upper bearings in place and apply clean grease to the bearing rollers (Figure 4-43).
6. Apply Loctite® 242 Threadlocker (Blue) to the two upper spray nozzles and install them into position. Make sure the slits in the face are vertical.

## Assembling the cover to the main body

Refer to Figure 4-47 when performing the following procedure:

1. Install the O-ring, and the oil gallery O-ring, between the main body and the cover.



Replace the O-ring if it has any flat spots, nicks, or is otherwise damaged.

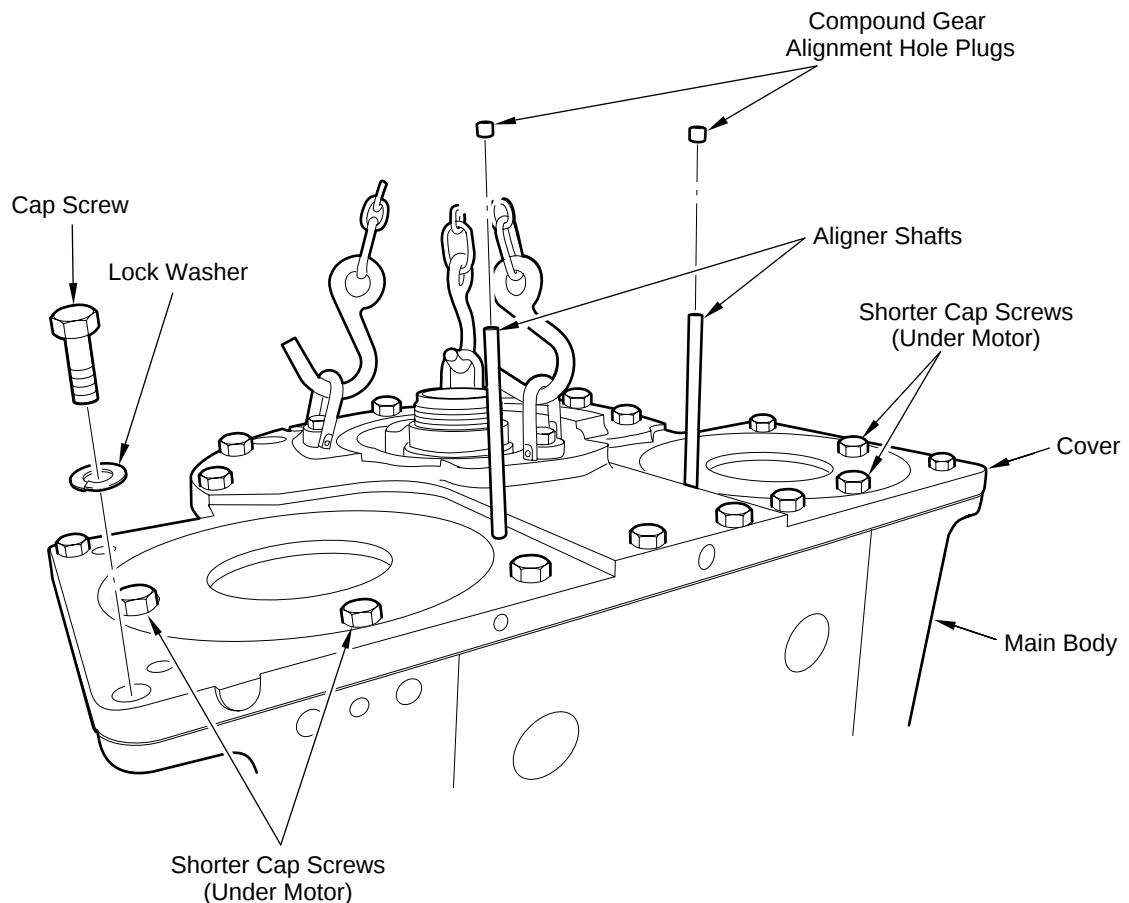
2. If the main body flange dowel pins have been removed, chill the new dowel pins to at least 0°F (-18°C), but no lower than -60°F (-51°C). Then drive the dowel pins into the alignment holes using a bronze hammer.
3. Apply a liberal amount of grease to the main body flange.
4. Install the compound gear aligner shafts into the compound gears until they are snug. Apply grease to the aligner shafts.
5. Pick up the cover and make sure the cover is level. With the compound gear alignment hole plugs out, lower the cover onto the main body, guiding the aligner shafts through the plug holes in the cover (Figure 4-47).

6. Apply an anti-seize compound to the threads of the 19 cover capscrews and install several cover capscrews to pull the cover down evenly. Install the remaining cover capscrews and sequentially torque all 19 capscrews to 250-270 ft lb. Safety wire the capscrews.



The cover capscrews located under the AC motor are 1/2 in. shorter than the other cover capscrews.

7. Remove the compound gear aligner shafts and install 1/2 in. NPT pipe plugs in the alignment holes. Apply thread sealer (not Teflon tape) to threads of the pipe plugs before installing them and make sure they are flush or below the level of the cover after installing them.



**Figure 4-47. Assembling the transmission/motor housing**



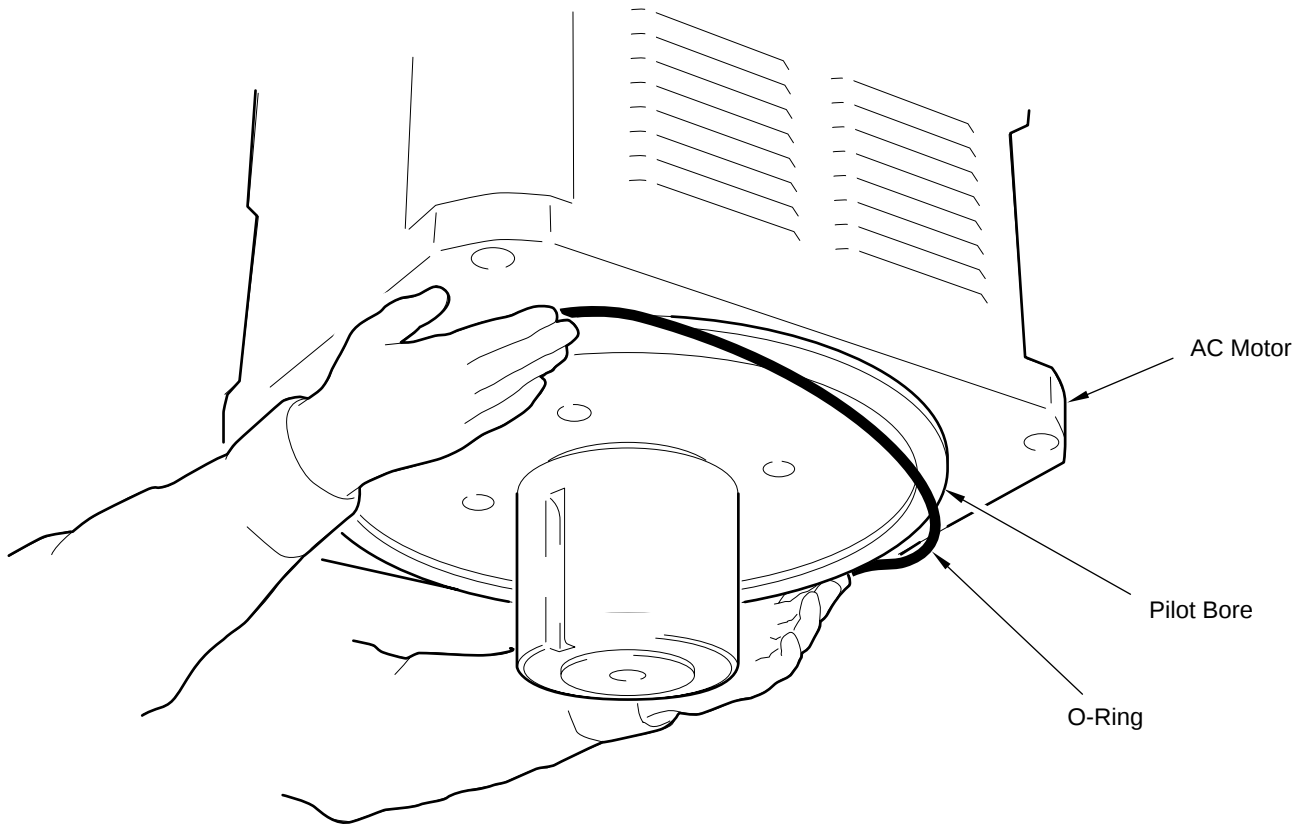
## Installing the AC drilling motors



This procedure assumes brakes and cooling systems are installed on the AC drilling motors as well as the pinion gears. For instructions on installing the brake hubs and pinion gears to the AC motor shafts see AC Drilling Motor Assembly.

Refer to Figure 4-43 when performing the following transmission/motor housing upper component procedures:

1. Inspect the O-rings that seal each AC drilling motor to the main body joint and replace any O-ring that has flat spots, nicks, or other damage. Place the O-rings on the pilot bore diameters and apply grease (Figure 4-48).



**Figure 4-48. Installing the AC drilling motors**

2. Pick up one of the AC motors by the brake end (using lifting straps placed under the brake adapter) and lower it into position on the pilot bore being careful not to move or crush the O-ring (Figure 4-48).

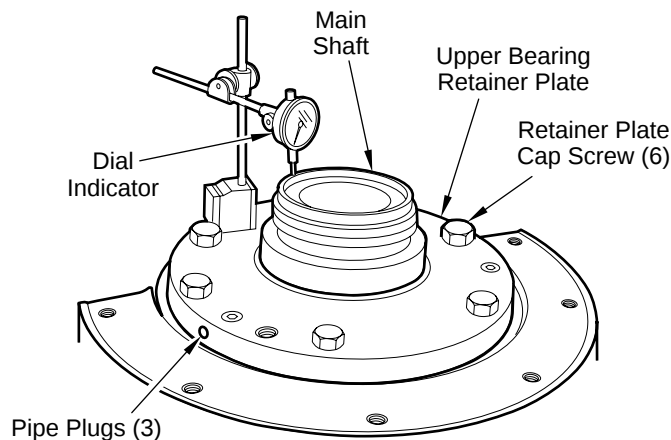


Make sure the brake end with mounting feet faces inboard and the blower duct faces the rear when installing the AC drilling motors.

3. Repeat step 2 for the second AC drilling motor.
4. Install the four capscrews and lockwashers that hold each AC drilling motor to the main body but do not tighten the bolts.
5. Install the hydraulic oil reservoir and the reservoir mounting bracket between the AC drilling motors. Do not tighten the bolts.
6. Measure the gaps between the motors and the front and rear of the reservoir mounting bracket. If this gap exceeds .010 in., install reservoir mounting shims as required.
7. Apply an anti-seize compound to the threads of the four main body cover bolts for each motor and the eight reservoir mounting bracket bolts. Tighten the four main body cover bolts to 250-270 ft lb, and then tighten the eight reservoir mounting bracket bolts to 610-670 ft lb. Safety wire the bolts.

## Installing the upper bearing retainer plate

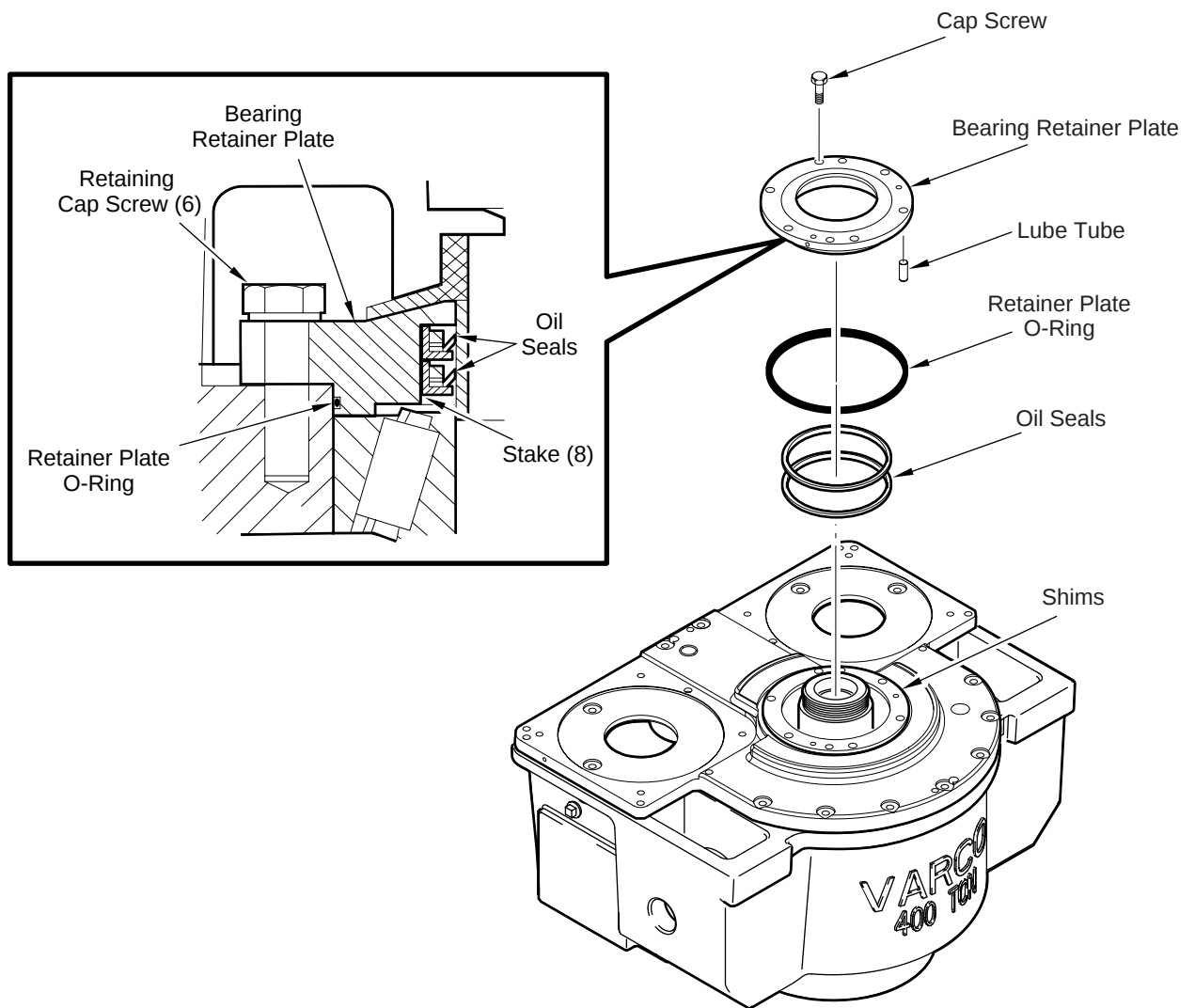
1. Grease the taper roller bearing on top of the main shaft. Chill the taper roller bearing outer race to at least 0°F (-18°C), then install the race into the cover bore.
2. Clean the retainer plate pipe plugs, apply thread sealer (not Teflon tape) to the pipe plug threads, and install the plugs into the retainer plate.
3. Determine the proper number of shims required under the bearing retainer plate by installing shims, installing the retainer plate, and checking the main shaft axial movement. Check main shaft axial movement by applying a force to the end of the main shaft and measuring the amount of axial movement at the other end with a dial indicator. Add or delete shims as necessary to obtain .001 in. to .002 in. of axial shaft movement (end play) with the retainer plate capscrews tightened to 250-270 ft lb (Figure 4-49).



**Figure 4-49. Measuring main shaft end play**



- Align the shims so that the upper bearing lube tube bore is not blocked.
3. Remove the bearing retainer plate capscrews and the bearing retainer plate.
4. Install the two new upper bonnet oil seals in the bearing retainer plate with the lips facing up (Figure 4-50).



**Figure 4-50. Upper bonnet oil seals**



*Use care not to damage the seals. Install the seals with the lips facing up since these seals function to keep mud from entering the main body.*

5. Using a center punch, stake the last seal in place on eight points.
6. Install the O-ring on the bearing retainer plate and coat the O-ring with grease.
7. Install two O-rings on the upper bearing lube tube and coat the O-rings with grease.

8. Install the lube tube into the lube tube bore in the cover with the .060 in. diameter hole facing up.
9. Install the bearing retainer plate, being careful to align the lube tube bore in the retainer with the lube tube protruding from the cover.
10. Carefully tap the bearing retainer plate to seat the plate on top of the cover.
11. Apply an anti-seize compound to the threads of the six bearing retainer plate capscrews, install the six capscrews and lockwashers, and tighten to 250-270 ft lb. Safety wire the capscrews.
12. Recheck the main shaft axial movement by applying a force to the main shaft and measuring the amount of axial movement with a dial indicator. The main shaft movement must be between .001 in. and .002 in. If the movement falls outside of this specification, readjust the number of shims under the bearing retainer plate.
13. Install two new grease fittings into the bearing retainer plate.

### **Installing the bonnet and wash pipe**

1. Install the new bearing shield on top of the main shaft. Hold the shield in place with a worm clamp.
2. Install the 3.875 in. OD polypack seal onto the upper stem liner with the O-ring facing away from the flange of the stem liner.
3. Lubricate the upper stem liner with grease and tap the liner in place on top of the main shaft.
4. Install the bonnet onto the pilot bore in the cover. Install nine 3/4 in. capscrews and lockwashers. Tighten the capscrews to 250-270 ft lb and safety wire the capscrews with .051 in. diameter lockwire.
5. Using a dial indicator, measure the run out of the main shaft to the S-pipe adapter bore in the bonnet. The TIR should not exceed .010 in.
6. Install the S-pipe adapter with eight 5/8 in. capscrews and lock washers. Tighten the capscrews to 145-155 ft lb. Safety wire the capscrews.

7. Using a dial indicator, measure the main shaft to adapter wash pipe pilot on the S-pipe adapter. The TIR should not exceed .006 in.
8. Install the wash pipe packing and tighten.
9. Grease the wash pipe packing and the bearing retainer plate seals.

## Checking the gear train backlash

1. Using feeler gauges, check the backlash of the primary and secondary gears through the access covers on the right side and left side of the main body (you can also use 3 in. NPT ports for access).



Backlash for the primary gears should be .007-.023 in. (.030 in. maximum). Backlash for the secondary gears should be .009-.030 in. (.040 in. maximum).

2. Install the main body right hand cover plate and cover gasket. Install the fourteen 1/2 in. capscrews and lockwashers and tighten to 71-79 ft lb. Safety wire the capscrews.
3. Install the four 3 in. pipe plugs.
4. Grease and install the O-rings on the bearing cover plates.
5. Install the two bearing cover plates with the 12 capscrews and lockwashers and tighten to 71-79 ft lb. Safety wire the capscrews.
6. Grease and install the O-rings on the oil pump and thermostat plate, then install the plate onto the left side of the main body with the ten 1/2 in. capscrews and lockwashers and tighten to 71-79 ft lb. Safety wire the capscrews.

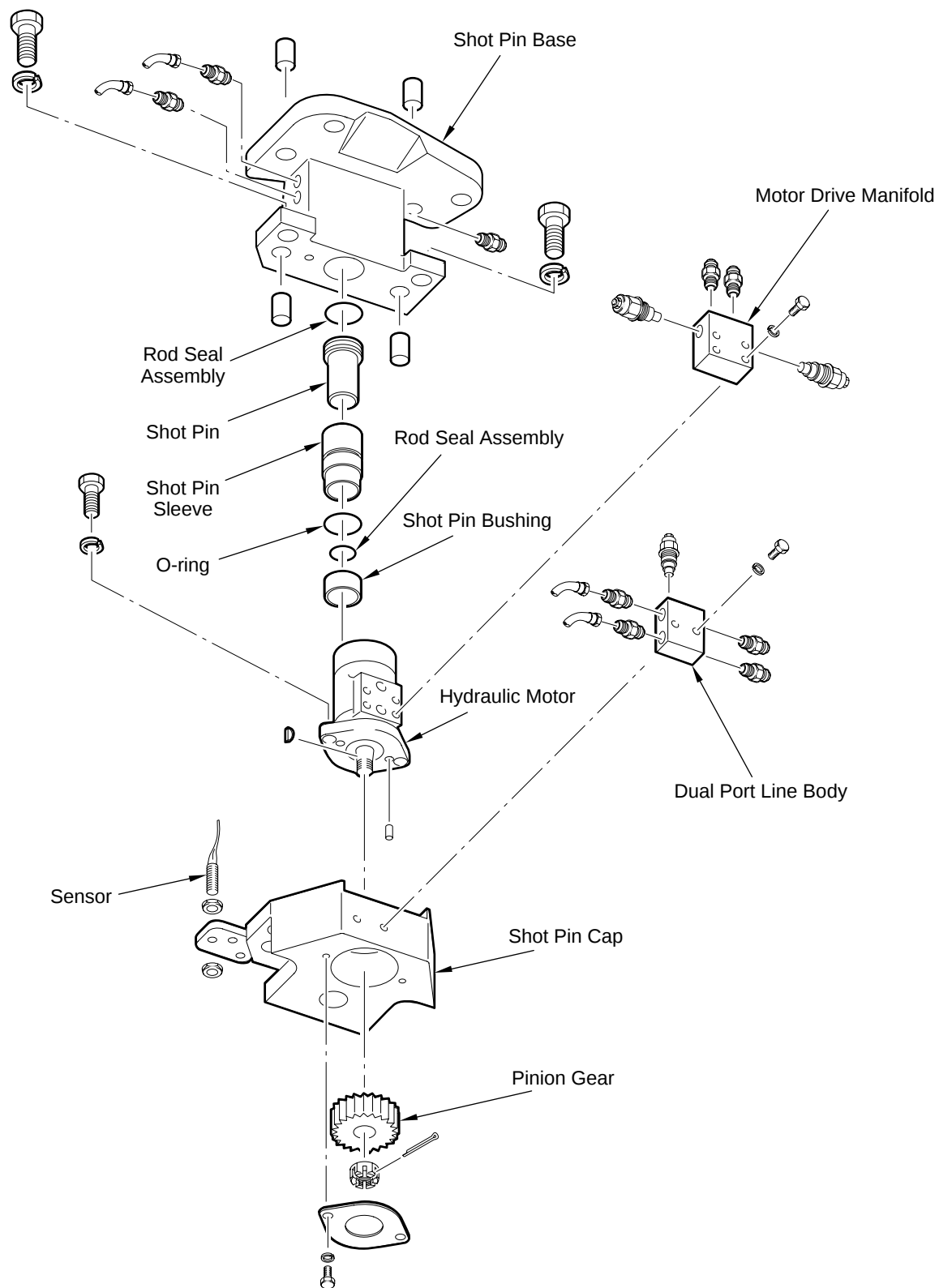
# Shot pin disassembly/assembly

---

Refer to Figure 4-51 when performing the following disassembly/assembly procedures:

1. Disconnect the hydraulic and electrical lines and remove the 10 HP AC motor/hydraulic pump assembly that is mounted to the shot pin assembly.
2. Remove the five 1 in. capscrews that attach the shot pin assembly to the main body.
3. Remove the four capscrews and lockwashers that hold the cylinder end cap in place.
4. Remove the shot pin components (end cap, O-rings, rod seal assemblies, shot pin, rod bearing).
5. Inspect the top bearing and press the bearing out of the shot pin mounting bracket if the bearing is scored or damaged.
6. Remove the two capscrews and washers that hold the safety retainer in place and remove the retainer.
7. Remove the capscrew, lockwasher, and flatwasher that hold the pinion gear in place, and remove the gear.
8. Remove the two capscrews and lockwashers that hold the hydraulic motor in place and remove the motor.

Inspect the disassembled parts and replace any worn or damaged parts. Assemble the shot pin assembly in reverse order of disassembly.



**Figure 4-51. Shot pin assembly**



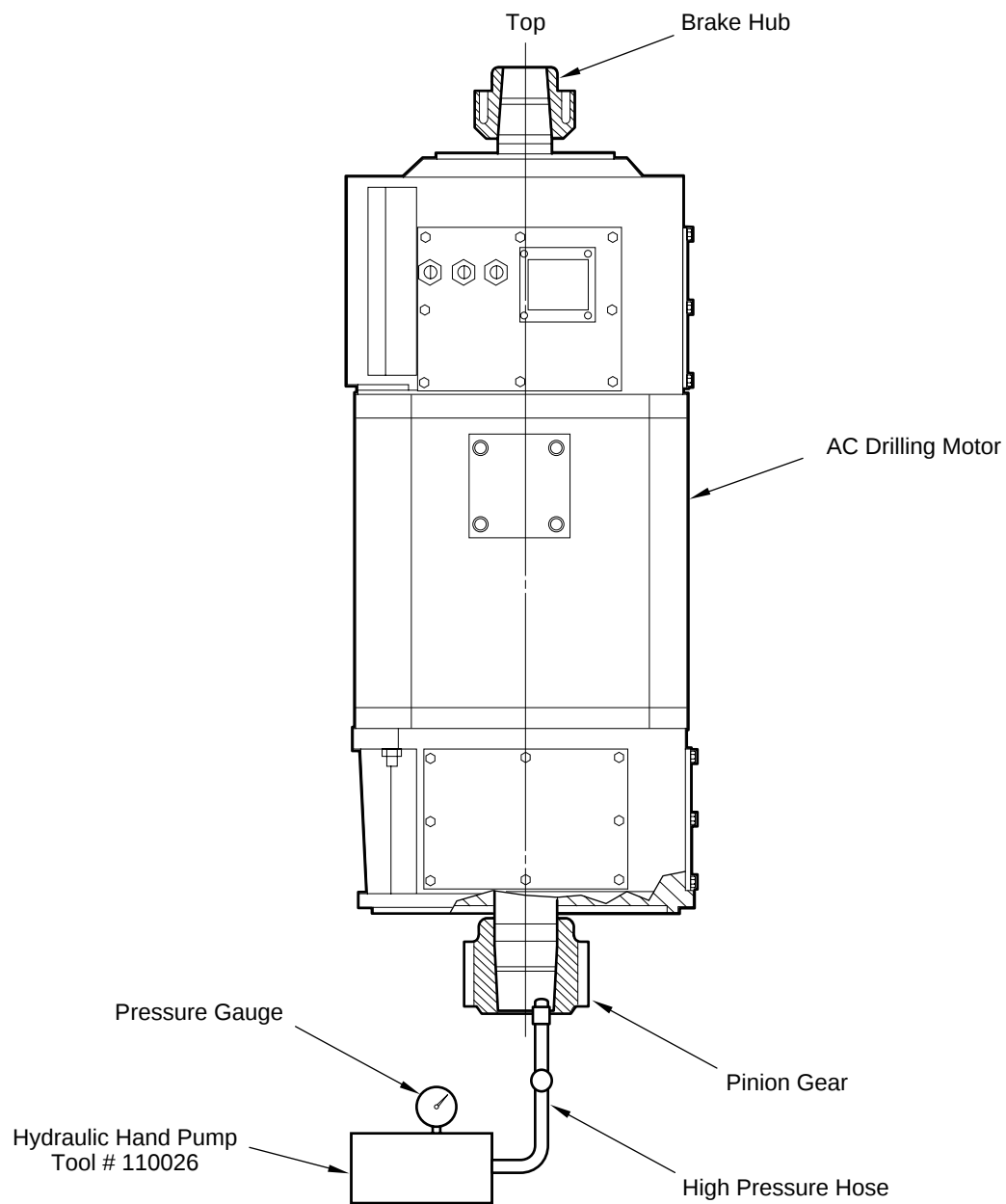
# AC drilling motor disassembly/assembly

---

## AC drilling motor disassembly

Each AC drilling motor has a brake hub on the top of the motor shaft, and a pinion gear at the bottom of the motor shaft as shown in Figure 4-52. When disassembling the brake hub and pinion gear from the motor shaft:

1. Obtain special tool 110026, a hydraulic hand pump with a gauge and high pressure hose, and connect as shown in Figure 4-52.
2. Increase the pressure to 35,000 psi and remove the brake hub.
3. Use the same procedure described in steps 1 and 2, to remove the pinion gear.

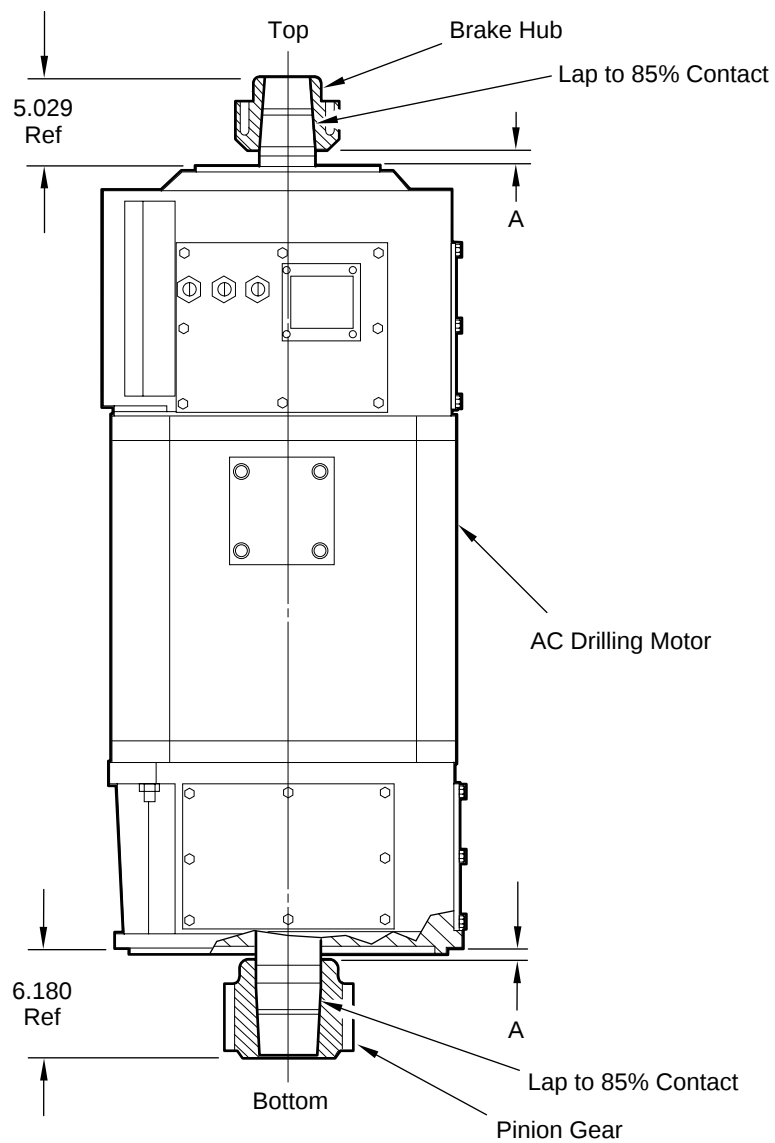


**Figure 4-52. AC drilling motor disassembly**

## AC drilling motor assembly

Each AC drilling motor has a brake hub installed on the top of the motor shaft, and a pinion gear installed at the bottom of the motor shaft as shown in Figure 4-53. When assembling the brake hub and pinion gear to the motor shaft:

1. Lap the brake hub and pinion gear to their respective ends of the motor shaft until the contact area between them is at least 85%.
2. Lightly install the brake hub and pinion gear onto the motor shaft and measure the gap to the motor (dimension "A").
3. Remove the brake hub and pinion gear and heat them in an oven to 400-425°F.
4. Reinstall the brake hub and pinion gear onto the motor shaft advancing the pinion gear  $.068 \pm .005$  inches and the brake hub  $.054 \pm .005$  inches past the original dimension "A". This ensures they remain securely fastened to the motor shaft.



**Figure 4-53. AC drilling motor assembly**

# Replacing the safety wiring

---

Use the following procedures to safety wire screws, nuts, bolts, or other fasteners where applicable.



***Torque fasteners before safety wiring any screw, nut, plug, or other fastener. Never overtorque or loosen a torqued fastener to align safety wire holes.***

Use the size and type of safety wire required in the applicable specifications and drawings. Whenever possible, use double-twist safety wiring.



***Limit single-twist wiring to the following: small screws located in closely spaced, closed geometrical patterns (e.g., triangle, square, rectangle, circle), parts in electrical systems, or parts that are difficult to reach.***

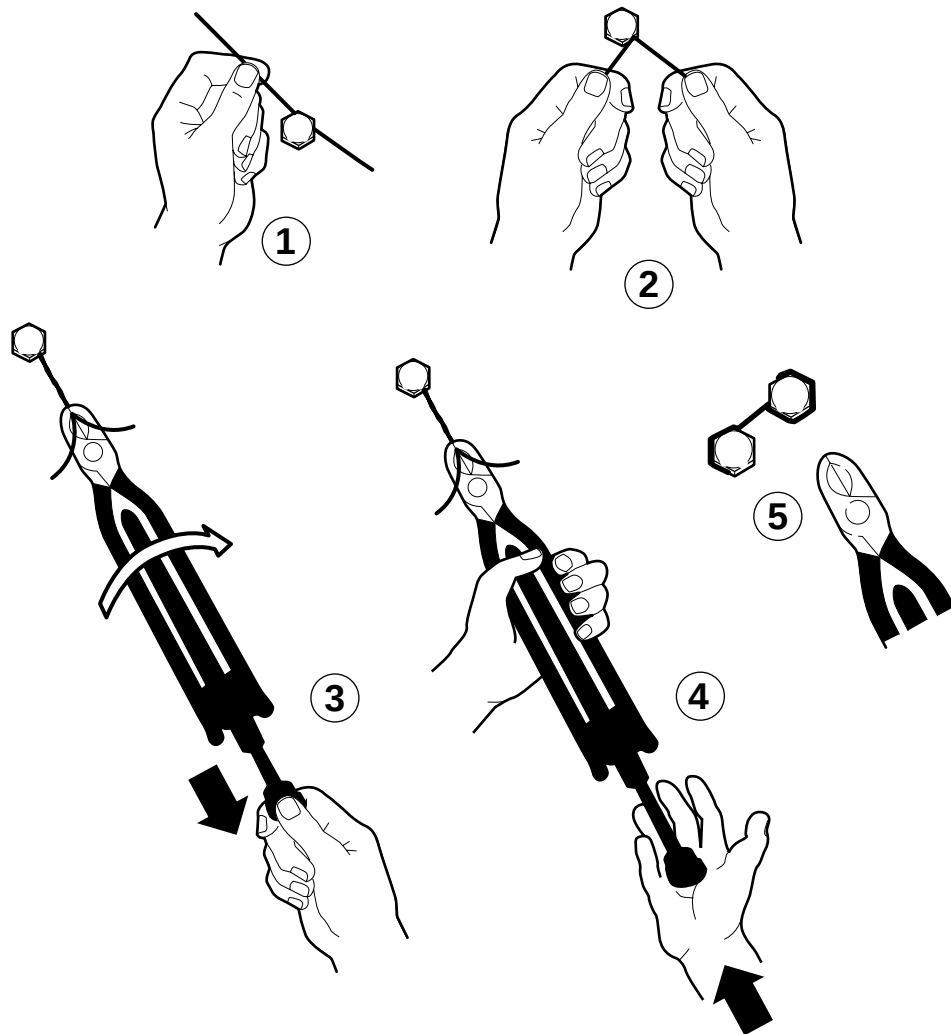


***Do not reuse safety wire.***

To install safety wire:

1. Open the jaws of the safety twist pliers:
2. Squeeze the handles of the pliers together and unlock the round, perforated slider in the center of the pliers from the hook lock.
3. Grip both safety wires in the jaw. Squeeze the handles together with one hand and pull the slider toward the rear of the pliers with the other hand to lock the pliers.
4. Twist the safety wire by pulling the aluminum knob and twist the rod out from the pliers. Let the pliers spin free.
5. Return the knob and twist the rod by holding the pliers steady with one hand and pushing against the end of the knob the with other hand (step 4 in Figure 4-54).
6. Repeat the previous twisting cycle.

7. After threading the safety wire through the hole in the fastener, pull the wire straight through without nicking the wire. Twist four to five complete revolutions per inch of wire.
8. Make a pigtail of approximately 1 in. (25 mm) length (four twists minimum) at the end of the wiring and bend back or under to prevent it from becoming a snag.



**Figure 4-54. Safety wiring procedures**

## Safety wiring tips

- ❑ Pull the safety wire firmly, but do not stretch it or let kinks develop. Make twists tight, even, and as taut as possible without weakening the wire by overtwisting (Figure 4-55).



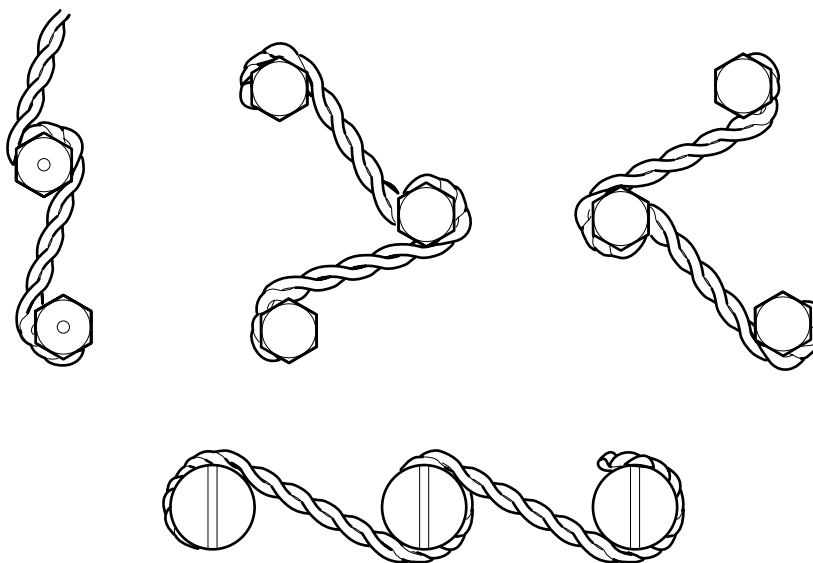
***Do not nick the wire with the edge of the hole in the fastener. Position the safety wire so the pull exerted by the wire tightens the nut. For best results, let the wire leave the fastener in a clockwise direction***

- ❑ Twist the safety wire so the loop around the bolt or head has sufficient tension to keep it from slipping up and over the bolt head, with resulting slack in the safety wiring.



***When securing castellated nuts with safety wire, tighten the nut to the low side of the selected torque range, unless otherwise specified. If necessary, continue tightening within specified torque limits until a slot aligns with the hole.***

- ❑ The number of nuts, bolts or screws that can be safety-wired together depends on the application. As a guide, when safety-wiring widely spaced bolts by the double-twist method, a group of three, or a 24 in. (610 mm) length of safety wire is usually the maximum.



**Figure 4-55. Safety wiring examples**

---

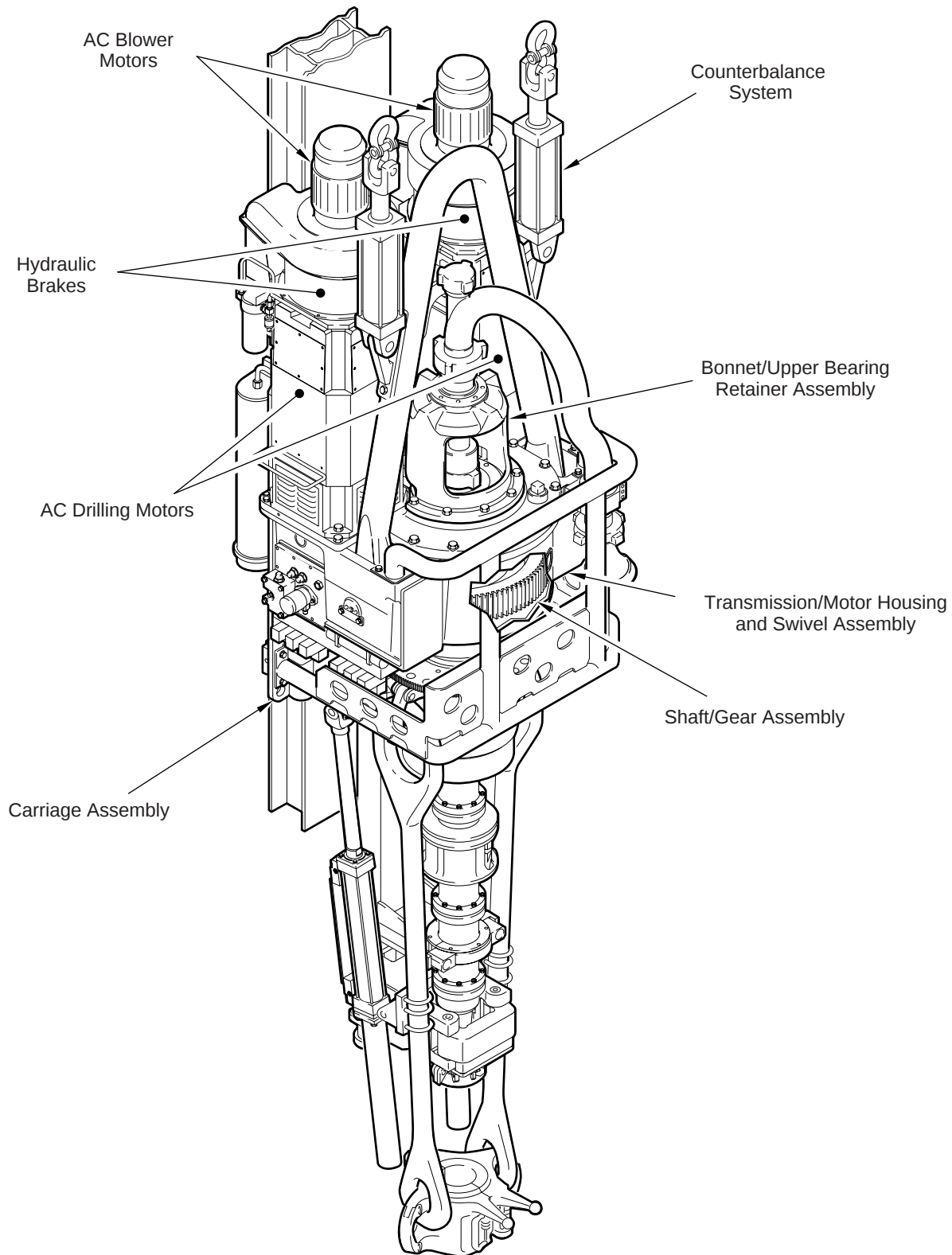
**TDS-9S**

**Top Drive  
Drilling  
System**

**Parts List**

---





**Figure 5-1. TDS-9S Drilling unit assembly**

# Contents

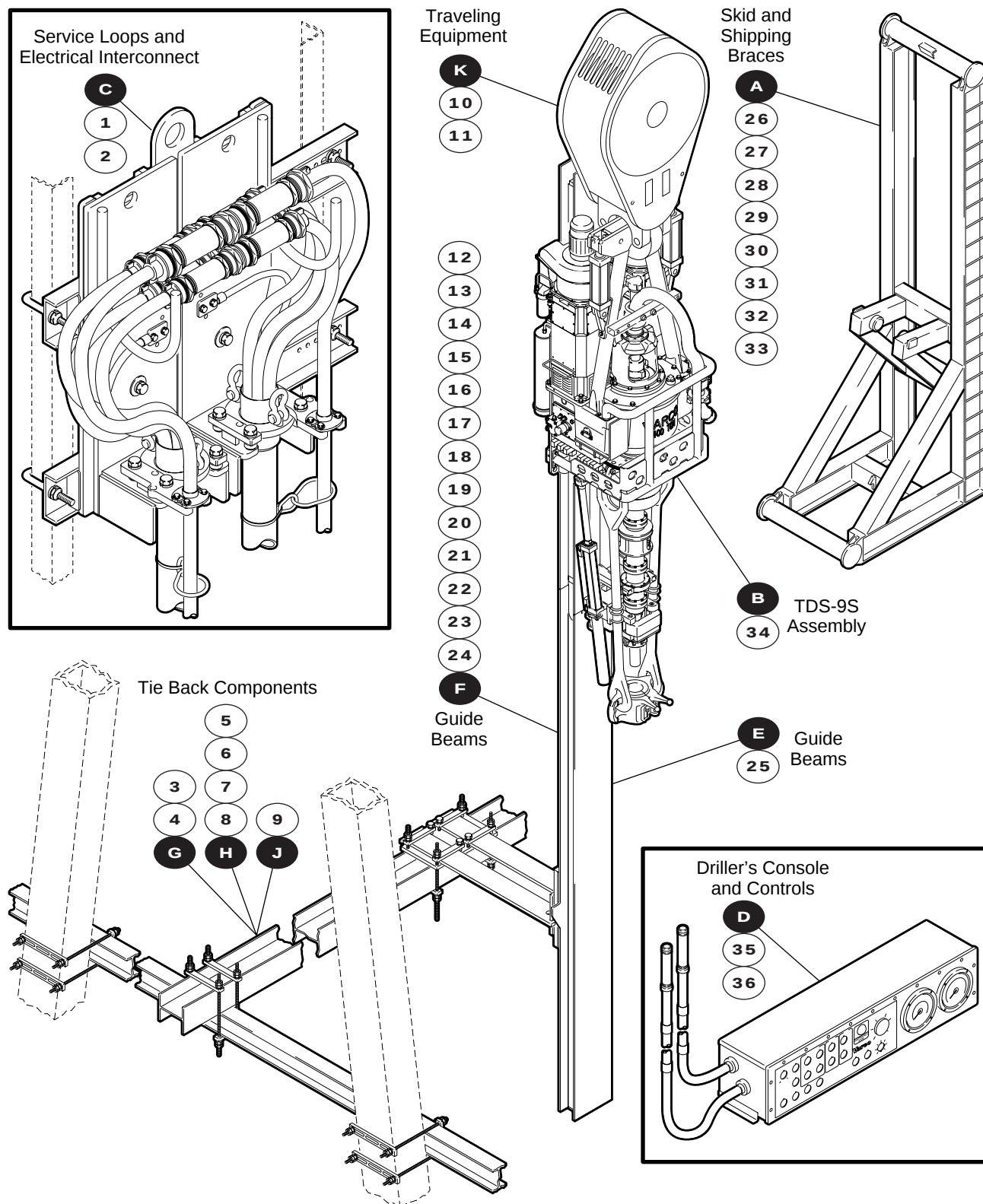
## Illustrated parts list

|                                                          |      |
|----------------------------------------------------------|------|
| Figure 5-1. TDS-9S Drilling unit assembly .....          | 5-2  |
| Figure 5-2. General arrangement .....                    | 5-6  |
| Figure 5-3. Shipping package .....                       | 5-10 |
| Figure 5-4. Link/link tilt/elevator .....                | 5-12 |
| Figure 5-5. Service loop .....                           | 5-16 |
| Figure 5-6. Driller's console .....                      | 5-18 |
| Figure 5-7. Guide beams (roller) .....                   | 5-22 |
| Figure 5-8. Guide beams (slider) .....                   | 5-24 |
| Figure 5-9. Universal tiebacks .....                     | 5-26 |
| Figure 5-10. Tiebacks (sliding) .....                    | 5-28 |
| Figure 5-11. Link tilt hydraulic cylinder assembly ..... | 5-30 |
| Figure 5-12. Intermediate tieback kit .....              | 5-34 |
| Figure 5-13. Traveling equipment attachment kit .....    | 5-36 |
| Figure 5-14. Bail assembly .....                         | 5-38 |
| Figure 5-15. Counterbalance assembly .....               | 5-40 |
| Figure 5-16. Motor guards .....                          | 5-44 |
| Figure 5-17. S-pipe .....                                | 5-46 |
| Figure 5-18. S-pipe (Hercules) .....                     | 5-48 |
| Figure 5-19. Torque arrestor assembly .....              | 5-50 |
| Figure 5-20. IBOP actuator .....                         | 5-54 |
| Figure 5-21. IBOP pipehandler .....                      | 5-56 |
| Figure 5-22. Bonnet/bearing retainer assembly .....      | 5-60 |
| Figure 5-23. Transmission/gearbox assembly .....         | 5-62 |
| Figure 5-24. Rotating link adapter (400 Ton) .....       | 5-66 |
| Figure 5-25. Rotating link adapter (350 Ton) .....       | 5-70 |
| Figure 5-26. Shot pin assembly .....                     | 5-74 |
| Figure 5-27. AC motor brake assembly, left .....         | 5-78 |

|                                                      |       |
|------------------------------------------------------|-------|
| Figure 5-28. AC motor brake assembly, right .....    | 5-82  |
| Figure 5-29. AC motor assembly .....                 | 5-86  |
| Figure 5-30. Gearbox lube pump assembly .....        | 5-88  |
| Figure 5-31. Carriage/accumulator (roller) .....     | 5-92  |
| Figure 5-32. Carriage assembly, right (roller) ..... | 5-94  |
| Figure 5-33. Carriage assembly, left (roller) .....  | 5-96  |
| Figure 5-34. Carriage/accumulator (skid) .....       | 5-98  |
| Figure 5-35. Carriage assembly, right (skid) .....   | 5-100 |
| Figure 5-36. Carriage assembly, left (skid) .....    | 5-102 |



# Illustrated parts list



**Figure 5-2. General arrangement**

**Key to Figure 5-2. General arrangement**

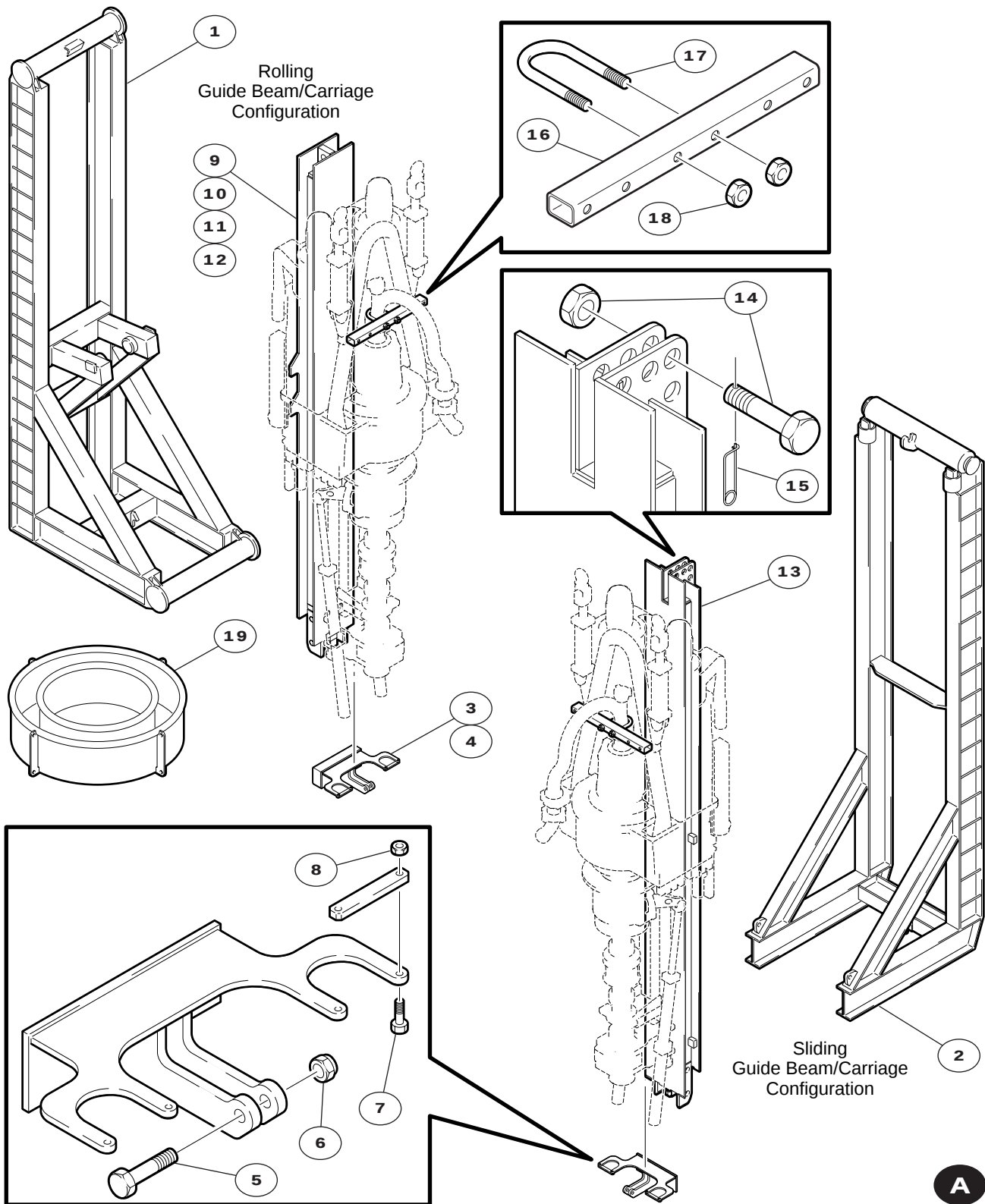
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                 | <b>Qty</b> |
|---------------|---------------|------------------------------------|------------|
| 1             | 116870        | Service Loop Installation Kit      | 1          |
| 2             | 117458        | Service Loop Kit                   | 1          |
| 3             | 117659        | Universal Tieback Kit              | 1          |
| 4             | 117659-1      | Universal Tieback Kit              | 1          |
| 5             | 117977        | Tieback Kit                        | 1          |
| 6             | 117977-100    | Tieback Kit                        | 1          |
| 7             | 117977-101    | Tieback Kit                        | 1          |
| 8             | 117977-102    | Tieback Kit                        | 1          |
| 9             | 118095        | Intermediate Tieback Kit           | 1          |
| 10            | 118244-HOOK   | Traveling Equipment Attachment Kit | 1          |
| 11            | 118244-BLOCK  | Traveling Equipment Attachment Kit | 1          |
| 12            | 117733-126    | Guide Beam Kit                     | 1          |
| 13            | 117733-136    | Guide Beam Kit                     | 1          |
| 14            | 117733-142    | Guide Beam Kit                     | 1          |
| 15            | 117733-147    | Guide Beam Kit                     | 1          |
| 16            | 117733-152    | Guide Beam Kit                     | 1          |
| 17            | 117733-226    | Guide Beam Kit                     | 1          |
| 18            | 117733-236    | Guide Beam Kit                     | 1          |
| 19            | 117733-242    | Guide Beam Kit                     | 1          |
| 20            | 117733-247    | Guide Beam Kit                     | 1          |
| 21            | 117733-252    | Guide Beam Kit                     | 1          |
| 22            | 117733-1LL    | Guide Beam Kit                     | 1          |
| 23            | 117733-2LL    | Guide Beam Kit                     | 1          |
| 24            | 117733-256    | Guide Beam Kit                     | 1          |

**Key to Figure 5-2. General arrangement (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>          | <b>Qty</b> |
|---------------|---------------|-----------------------------|------------|
| 25            | 121334        | Guide Beam Kit              | 1          |
| 26            | 114755        | Shipping Package            | 1          |
| 27            | 114755-1      | Shipping Package            | 1          |
| 28            | 114755-2      | Shipping Package            | 1          |
| 29            | 114755-3      | Shipping Package            | 1          |
| 30            | 114755-4      | Shipping Package            | 1          |
| 31            | 114755-5      | Shipping Package            | 1          |
| 32            | 114755-6      | Shipping Package            | 1          |
| 33            | 119320        | Shipping Package            | 1          |
| 34            | 115216        | General Information Drawing | 1          |
| 35            | 116288        | VDC w/Pigtails Kit          | 1          |
| 36            | 116288-1      | VDC w/Pigtails Kit          | 1          |



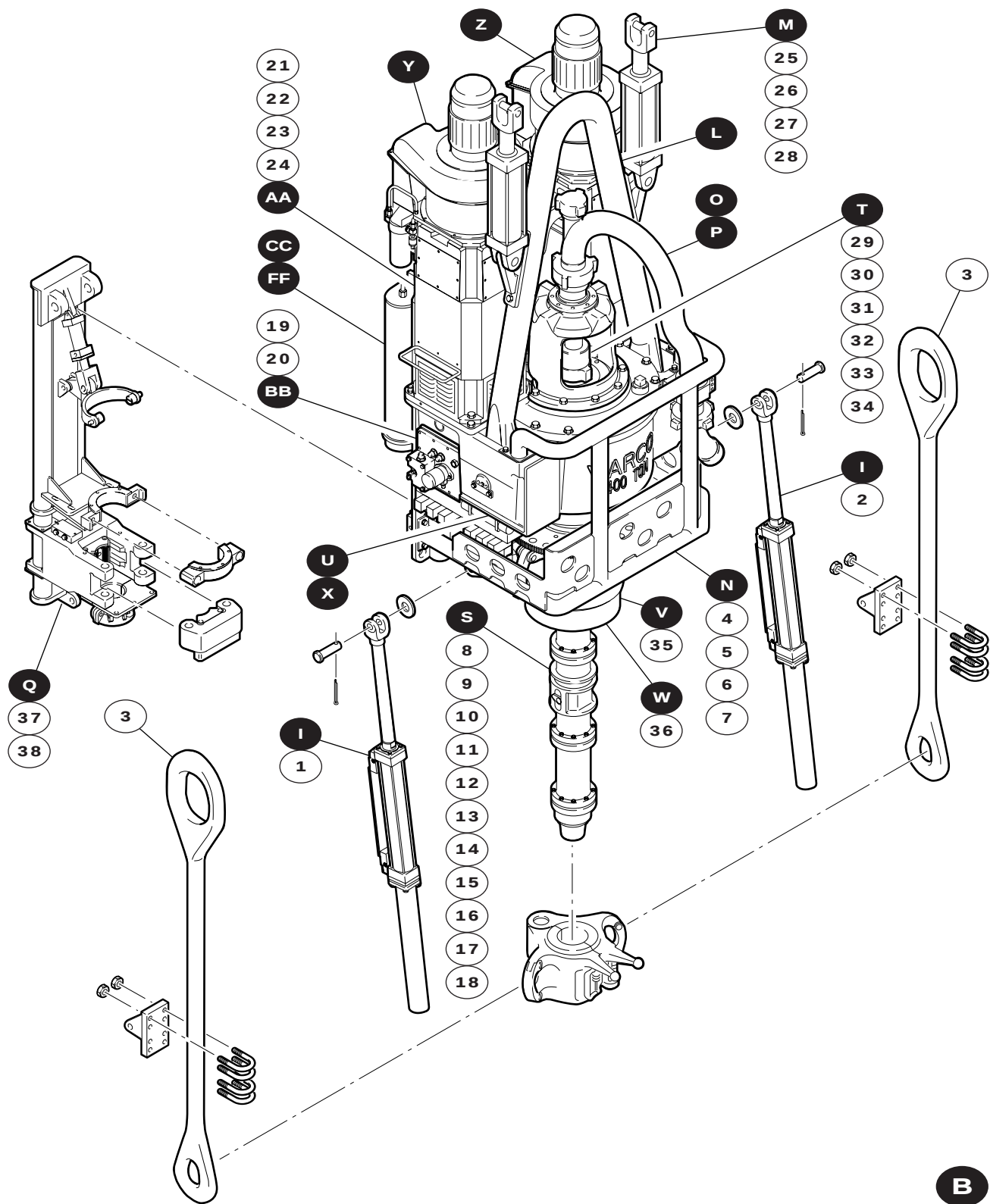




**Figure 5-3. Shipping package**

**Key to Figure 5-3. Shipping package**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                                 | <b>Qty</b> |
|---------------|---------------|----------------------------------------------------|------------|
| 1             | 112944        | Shipping Skid                                      | 1          |
| 2             | 119048        | Skid                                               | 1          |
| 3             | 117909        | Bracket, 30.00" Setback Skid                       | 1          |
| 4             | 117909-501    | Bracket, 33.75" Setback Skid                       | 1          |
| 5             | 50016-40-C5   | Hex-head Screw, 1.00-8 x 4.50                      | 1          |
| 6             | 51816-C       | Hex Nut, Self-Locking, 1.00-8                      | 1          |
| 7             | 50008-12-5    | Hex-head Screw, .50-13 x 1.50                      | 4          |
| 8             | 50408-C       | Hex Nut, Self-Locking, 1.00-8                      | 4          |
| 9             | 112229        | Guide Beam, Top Section, Welded Hinges             | 1          |
| 10            | 112229-500    | Guide Beam, Top Section, Welded Hinges, Dual Wings | 1          |
| 11            | 116705        | Guide Beam, Top Section, Cast Hinges               | 1          |
| 12            | 116705-500    | Guide Beam, Top Section, Cast Hinges, Dual Wings   | 1          |
| 13            | 117617        | Guide Beam, Top Section                            | 1          |
| 14            | 95523-1       | Bolt Assembly                                      | 1          |
| 15            | 112960        | Safety Pin                                         | 1          |
| 16            | 113498        | Tube, 3" x 5" x 32"                                | 1          |
| 17            | 113497        | U-Bolt, 3/4-10                                     | 1          |
| 18            | 50212-C       | Nut, 3/4-10                                        | 2          |
| 19            | 108684        | Service Loop Tub                                   | 1          |



**Figure 5-4. Link/link tilt/elevator**

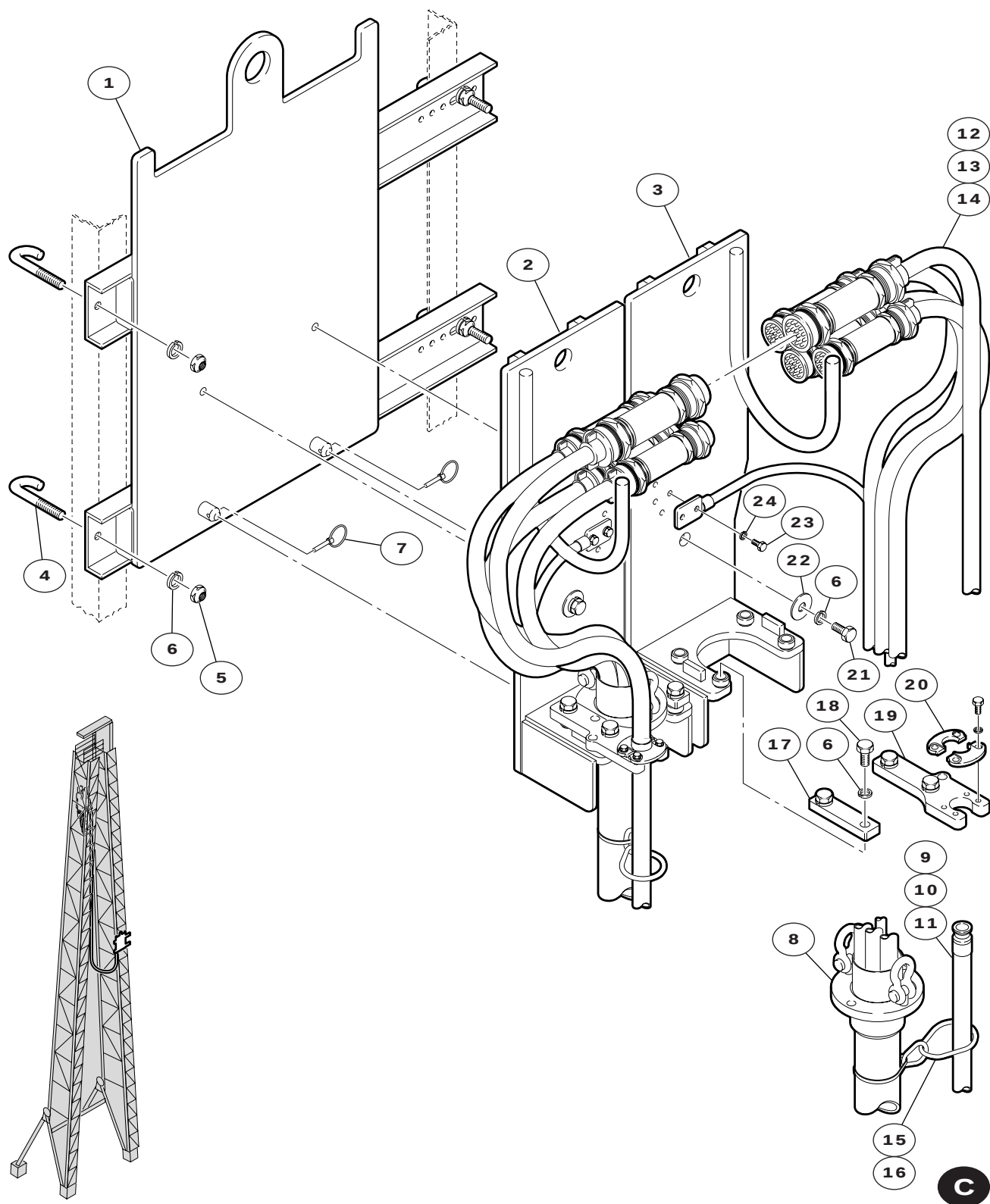
**Key to Figure 5-4. Link/link tilt/elevator**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                     | <b>Qty</b> |
|---------------|---------------|----------------------------------------|------------|
| 1             | 113993-1      | Link Tilt Assembly, Right              | 1          |
| 2             | 113993        | Link Tilt Assembly, Left               | 1          |
| 3             | 26940Y1108    | Elevator Link, 350 Ton x 108" long     | 1          |
| 4             | 110006        | Motor Housing Guard                    | 1          |
| 5             | 121740        | Motor Housing Guard, EEx Package       | 1          |
| 6             | 121808        | Motor Housing Guard, UK Rental Package | 1          |
| 7             | 120917        | Motor Housing Guard, Package           | 1          |
| 8             | 110050        | Pipehandler Package, PH-50             | 1          |
| 9             | 110050-1      | Pipehandler Package, PH-50             | 1          |
| 10            | 110050-2      | Pipehandler Package, PH-50             | 1          |
| 11            | 110050-3      | Pipehandler Package, PH-50             | 1          |
| 12            | 110050-4      | Pipehandler Package, PH-50             | 1          |
| 13            | 110050-5      | Pipehandler Package, PH-50             | 1          |
| 14            | 110050-6      | Pipehandler Package, PH-50             | 1          |
| 15            | 110050-7      | Pipehandler Package, PH-50             | 1          |
| 16            | 110050-8      | Pipehandler Package, PH-50             | 1          |
| 17            | 110050-9      | Pipehandler Package, PH-50             | 1          |
| 18            | 110050-10     | Pipehandler Package, PH-50             | 1          |
| 19            | 109540        | Gearbox Lubrication Pump Assembly      | 1          |
| 20            | 109540-1      | Gearbox Lubrication Pump Assembly      | 1          |
| 21            | 108537-35R60  | AC Drill Motor Assembly                | 1          |
| 22            | 108537-35L60  | AC Drill Motor Assembly                | 1          |
| 23            | 108537-35R46  | AC Drill Motor Assembly                | 1          |
| 24            | 108537-35L46  | AC Drill Motor Assembly                | 1          |

***Key to Figure 5-4. Link/link tilt/elevator (continued)***

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                      | <b>Qty</b> |
|---------------|---------------|-----------------------------------------|------------|
| 25            | 112190        | Counterbalance Package                  | 1          |
| 26            | 112190-120H   | Counterbalance Package                  | 1          |
| 27            | 112190-120B   | Counterbalance Package                  | 1          |
| 28            | 112190-120    | Counterbalance Package                  | 1          |
| 29            | 91249         | Wash Pipe Assembly                      | 1          |
| 30            | 91249-500     | Wash Pipe Assembly                      | 1          |
| 31            | 91249-501     | Wash Pipe Assembly                      | 1          |
| 32            | 91249-502     | Wash Pipe Assembly                      | 1          |
| 33            | 91249-503     | Wash Pipe Assembly                      | 1          |
| 34            | 91249-504     | Wash Pipe Assembly                      | 1          |
| 35            | 113690        | Rotating Link Adapter Assembly, 400 Ton | 1          |
| 36            | 110135        | Rotating Link Adapter Assembly, 350 Ton | 1          |
| 37            | 110140        | Torque Arrestor Assembly                | 1          |
| 38            | 110140-1      | Torque Arrestor Assembly                | 1          |



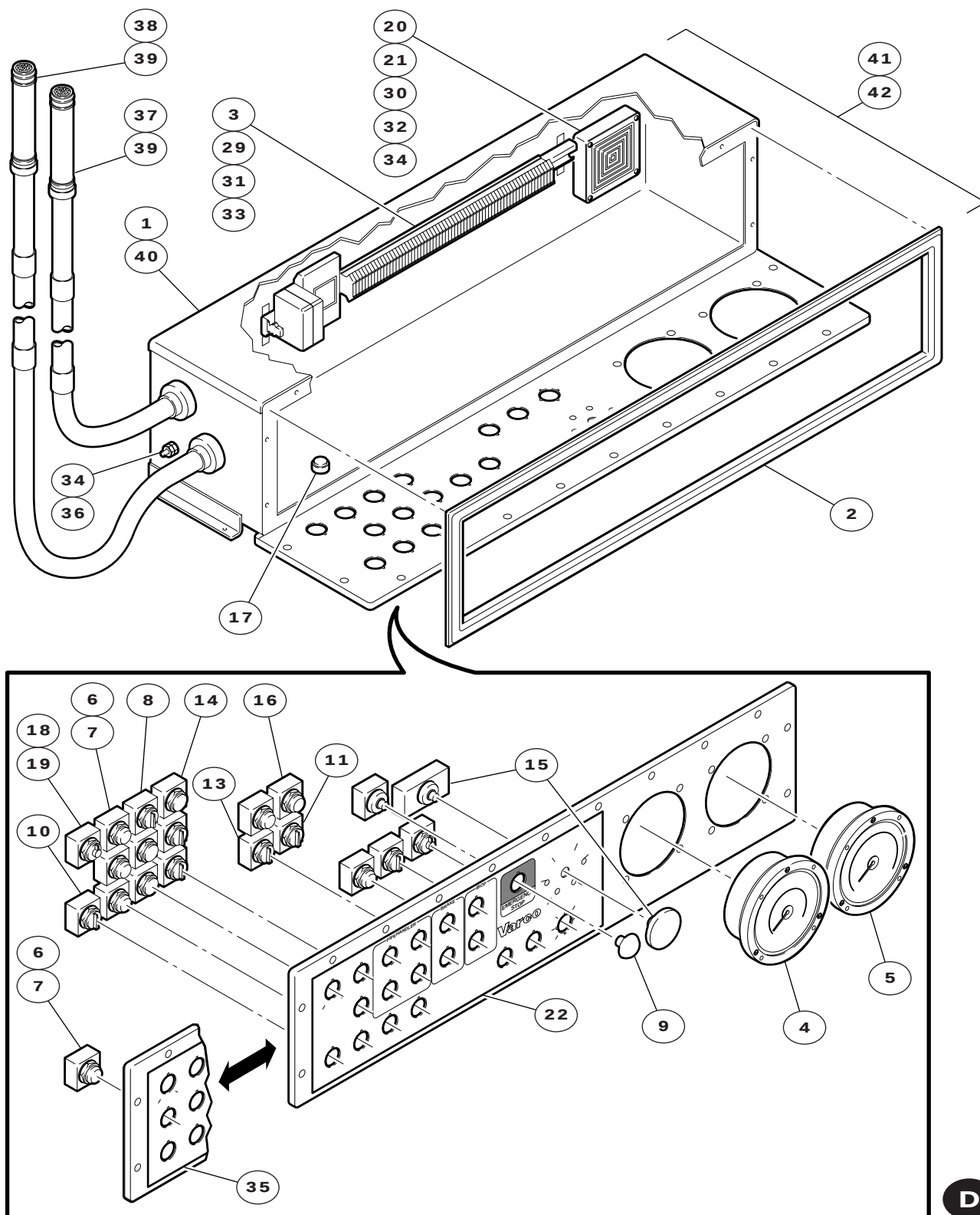


**Figure 5-5. Service loop**

**Key to Figure 5-5. Service loop**

| <b>Item #</b> | <b>Part #</b>   | <b>Description</b>                     | <b>Qty</b> |
|---------------|-----------------|----------------------------------------|------------|
| 1             | 116867          | Derrick Leg Plate                      | 1          |
| 2             | 116868          | Service Loop Bracket                   | 1          |
| 3             | 116868-500      | Service Loop Bracket                   | 1          |
| 4             | 116869          | Clamp J-Bolt                           | 4          |
| 5             | 51812-C         | Hex-head Nut, Self-Locking, .75-10     | 4          |
| 6             | 50912-C         | Lock Washer, Reg., .75                 | 14         |
| 7             | 7887            | Hitch Pin                              | 2          |
| 8             | 107714          | Service Loop Mount                     | 2          |
| 9             | 116827-65-4-3-B | Control Loop Assembly, with Connectors | 1          |
| 10            | 116827-75-4-3-B | Control Loop Assembly, with Connectors | 1          |
| 11            | 116827-86-4-3-B | Control Loop Assembly, with Connectors | 1          |
| 12            | 116779-65-4-3-B | Control Loop Assembly, with Connectors | 1          |
| 13            | 116779-75-4-3-B | Control Loop Assembly, with Connectors | 1          |
| 14            | 116779-86-4-3-B | Control Loop Assembly, with Connectors | 1          |
| 15            | 117121-500      | Cable Tie                              | 24         |
| 16            | 117125          | Ring Assembly                          | 8          |
| 17            | 78002           | Clamp                                  | 2          |
| 18            | 50012-24-C5D    | Hex-head Cap Screw, .75-10 x 3.00      | 8          |
| 19            | 107714          | Composite Cable Mount                  | 2          |
| 20            | 56541-32        | Split Flange Kit                       | 2          |
| 21            | 50012-14-C5D    | Hex-head Cap Screw, .75-10 x 1.75      | 2          |
| 22            | 50812-W-C       | Flat Washer, Wide, .75                 | 2          |
| 23            | 50008-8-C5D     | Hex-head Cap Screw, .50-13 x 1.00      | 4          |
| 24            | 50908-C         | Lock Washer, Reg., .50                 | 12         |





**Figure 5-6. Driller's console**

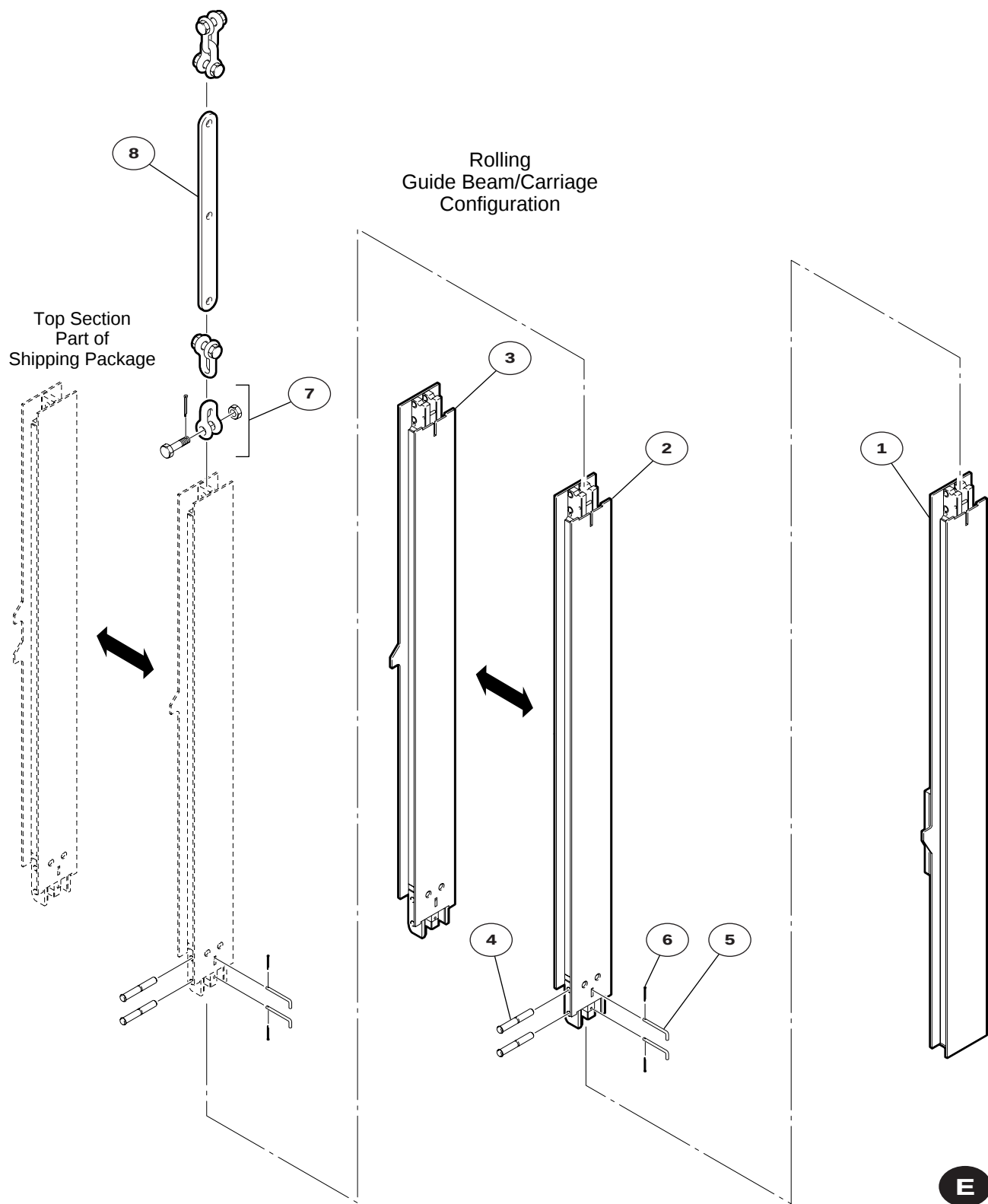
**Key to Figure 5-6. Driller's console**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                         | <b>Qty</b> |
|---------------|---------------|--------------------------------------------|------------|
| 1             | 110745        | Enclosure Weldment                         | 1          |
| 2             | 88042-10      | Enclosure Gasket                           | 1          |
| 3             | 117562        | Terminal Block Assembly                    | 1          |
| 4             | 96219-7       | Torque Meter, 0-10 VDC (0-50,000 ft lb)    | 1          |
| 5             | 96218-3       | RPM Meter, 0-10 VDC (0-250 rpm)            | 1          |
| 6             | 87708-38      | Indicating Light, Red                      | 5          |
| 7             | 87708-44      | Indicating Lamp, 2 Watt                    | 6          |
| 8             | 87708-30      | 3-Position Spring Return-to-Center Switch  | 1          |
| 9             | 87708-67      | Emergency Stop Pushbutton, Mushroom        | 1          |
| 10            | 87708-33      | 3-Position Spring Return-from-Right Switch | 1          |
| 11            | 87708-26      | 2-Position Maintained Selector Switch      | 2          |
| 13            | 87708-36      | 3-Position Maintained Selector Switch      | 3          |
| 14            | 87708-02      | Pushbutton Switch                          | 3          |
| 15            | 116551        | Rheostat Assembly, Throttle, IDM Controls  | 1          |
| 16            | 87708-40      | Indicating Light, Amber                    | 1          |
| 17            | 53000-2-B     | Ext. Pipe Plug, Brass                      | 1          |
| 18            | 87708-46      | Potentiometer, Operator                    | 2          |
| 19            | 81736-2       | Potentiometer, 10K                         | 2          |
| 20            | 88663         | Horn J-Box                                 | 1          |
| 21            | 87124         | Horn, 24 VDC                               | 1          |
| 22            | 117601-BSC    | VDC Nameplate                              | 1          |
| 29            | 50649-63      | Pan-head Machine Screw, SST, 10-32 x .50   | 2          |
| 30            | 50802-R-S     | Flat Washer, No. 8                         | 2          |
| 31            | 50803-R-S     | Flat Washer, No. 10                        | 2          |

***Key to Figure 5-6. Driller's console (continued)***

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                       | <b>Qty</b> |
|---------------|---------------|------------------------------------------|------------|
| 32            | 50902-S       | Lock Washer, Reg., No. 8                 | 2          |
| 33            | 50903-S       | Lock Washer, Reg., No. 10                | 2          |
| 34            | 50202-S       | Hex-head Nut, Std., 8-32                 | 8          |
| 35            | 117601-1      | VDC Nameplate, with Purge                | 1          |
| 37            | 117337        | Cable Assembly, 37 Cond., (VDC)          | 1          |
| 38            | 117336        | Cable Assembly, 12 TSP (VDC)             | 1          |
| 39            | 83444-10      | Glands                                   | 2          |
| 40            | 98587         | Purge System                             | 1          |
| 41            | 117552        | Driller's Console Assembly               | 1          |
| 42            | 117552-1      | Driller's Console Assembly, with Z-Purge | 1          |





E

**Figure 5-7. Guide beams (roller)**

***Key to Figure 5-7. Guide beams (roller)***

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                       | <b>Qty</b> |
|---------------|---------------|------------------------------------------|------------|
| 1             | 116414-505    | Guide Beam, Bottom Section               | 1          |
| 2             | 115954        | Guide Beam, Intermediate Section         | 4          |
| 3             | 115954-500    | Guide Beam, Special Intermediate Section | 1          |
| 4             | 116644        | Retaining Pin                            | 12         |
| 5             | 116643        | Hinge Pin                                | 12         |
| 6             | 51403-8-S     | Cotter Pin                               | 12         |
| 7             | 89035-1       | Shackle, 25 Ton                          | 4          |
| 8             | 99873-650     | Connection Link, 65"                     | 1          |

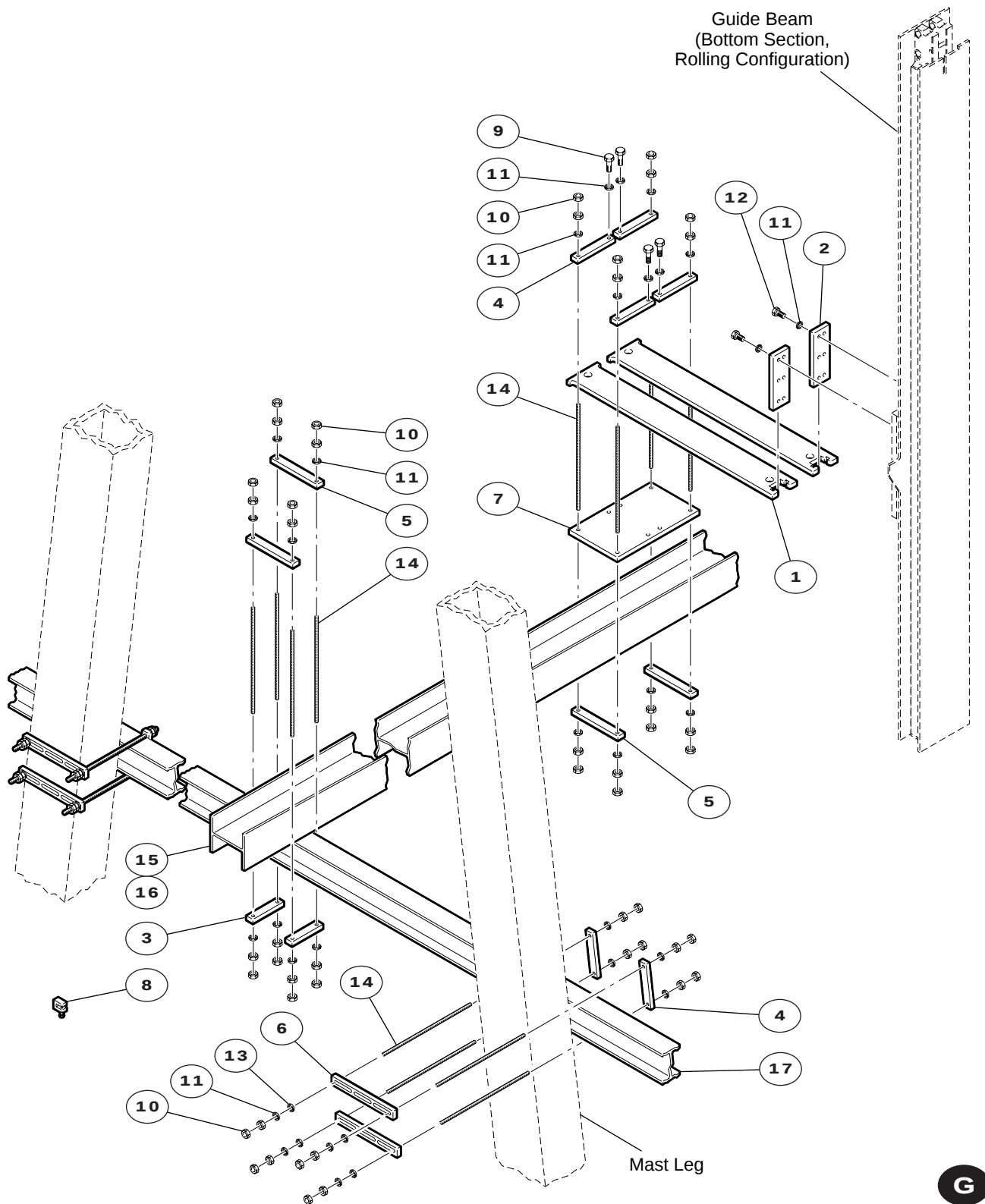


**Figure 5-8. Guide beams (slider)**

***Key to Figure 5-8. Guide beams (slider)***

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                       | <b>Qty</b> |
|---------------|---------------|------------------------------------------|------------|
| 1             | 117618        | Guide Beam, Bottom Section (18 ft)       | 1          |
| 2             | 117618-500    | Guide Beam, Bottom Section (36 ft)       | 1          |
| 3             | 117616        | Guide Beam, Intermediate Section (18 ft) | 4,5,6      |
| 4             | 117616-500    | Guide Beam, Intermediate Section (36 ft) | 2          |
| 5             | 117783        | Retainer Pin                             | 3,5,6,7    |
| 6             | 117782        | Joint Pin                                | 3,5,6,7    |
| 7             | 117496-1      | Lynch Pin                                | 3,5,6,7    |
| 8             | 95523         | Shackle, 25 Ton                          | 1          |
| 9             | 117788-136    | Hang-Off Link                            | 1          |
| 10            | 117788-142    | Hang-Off Link                            | 1          |
| 11            | 117788-147    | Hang-Off Link                            | 1          |
| 12            | 117788-152    | Hang-Off Link                            | 1          |
| 13            | 117788-126    | Hang-Off Link                            | 1          |
| 14            | 117788-156    | Hang-Off Link                            | 1          |

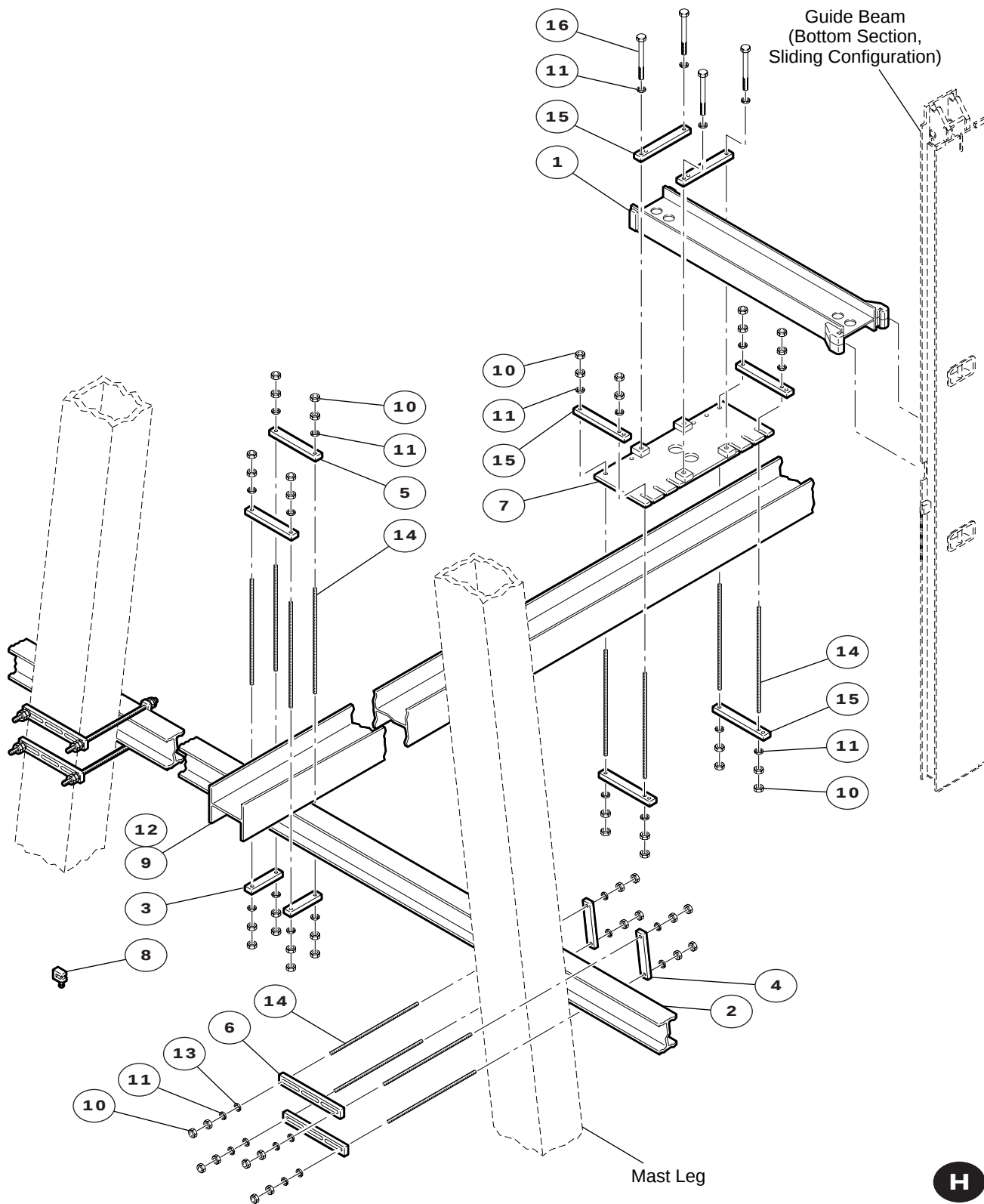




**Figure 5-9. Universal tiebacks**

**Key to Figure 5-9. Universal tiebacks**

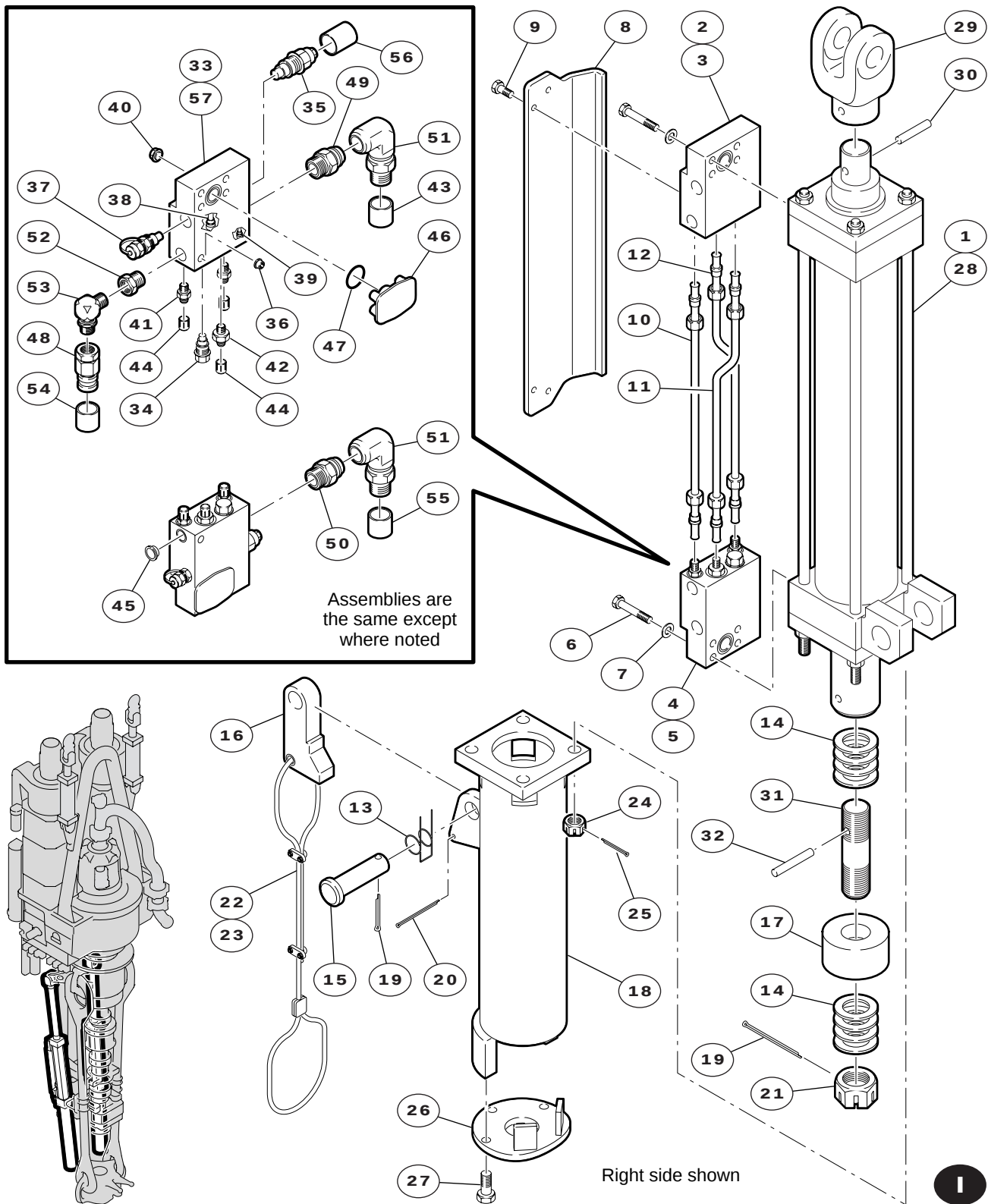
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>            | <b>Qty</b> |
|---------------|---------------|-------------------------------|------------|
| 1             | 117698        | Tieback Link                  | 2          |
| 2             | 117699        | Attachment Plate              | 2          |
| 3             | 117700-1      | Strap                         | 4          |
| 4             | 117700-2      | Strap                         | 12         |
| 5             | 117700-3      | Strap                         | 6          |
| 6             | 117701        | Strap                         | 8          |
| 7             | 117702        | Tieback Plate                 | 1          |
| 8             | 117731        | Flange Clamp                  | 20         |
| 9             | 50016-32-C5   | Screw, 1-8 UNC x 4.0 long     | 4          |
| 10            | 50416-C       | Nut, 1-8 unc                  | 112        |
| 11            | 50916-C       | Lock Washer, 1"               | 72         |
| 12            | 50016-20-C5   | Screw, 1-8 unc x 2.5 long     | 12         |
| 13            | 50816-R-C-5   | Flat Washer, 1"               | 16         |
| 14            | 112893-1      | Threaded Rod, 1-8 x 36" long  | 28         |
| 15            | 117659-15     | Plate, 1.00 Thick             | 1          |
| 16            | 117659-16     | Beam, W 12 x 72 x 384.0 long  | 1          |
| 17            | 117659-17     | Beam, W 8 x 18 x 144.0 long   | 2          |
| 18            | 117659-DWG    | Universal Tieback Kit Drawing | 1          |



**Figure 5-10. Tiebacks (sliding)**

**Key to Figure 5-10. Tiebacks (sliding)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>           | <b>Qty</b> |
|---------------|---------------|------------------------------|------------|
| 1             | 117976        | Tieback Link                 | 1          |
| 2             | 117977-2      | Beam, W 8 x 18 x 180.0 long  | 2          |
| 3             | 117700-1      | Strap                        | 4          |
| 4             | 117700-2      | Strap                        | 8          |
| 5             | 117700-3      | Strap                        | 4          |
| 6             | 117701        | Strap                        | 8          |
| 7             | 117982        | Tieback Plate                | 1          |
| 8             | 117731        | Flange Clamp                 | 6,8        |
| 9             | 117977-9      | Beam, W 12 x 72 x 384.0 long | 1          |
| 10            | 50416-C       | Nut, 1-8 unc                 | 16,32,64   |
| 11            | 50916-C       | Lock Washer, 1"              | 8,20,32    |
| 12            | 117977-12     | Plate, 1.00 thick            | 1          |
| 13            | 50816-R-C-5   | Flat Washer, 1"              | 16         |
| 14            | 112893-1      | Threaded Rod, 1-8 x 36" long | 4,8,16     |
| 15            | 119973        | Strap                        | 6          |
| 16            | 50016-64-C5D  | Bolt, 1.00 unc x 8.0 long    | 5          |



**Figure 5-11. Link tilt hydraulic cylinder assembly**

**Key to Figure 5-11. Link tilt hydraulic cylinder assembly**

| Item # | Part #       | Description                                             | Qty |
|--------|--------------|---------------------------------------------------------|-----|
| 1      | 119311       | Double Rod Hydraulic Cylinder, 4" dia. x 2.5" rod x 26" | 1   |
| 2      | 117864       | Link Tilt Cylinder Manifold Assembly                    | 1   |
| 3      | 117865       | Link Tilt Cylinder Manifold Assembly                    | 1   |
| 4      | 117864-1     | Link Tilt Cylinder Manifold Assembly                    | 1   |
| 5      | 117865-1     | Link Tilt Cylinder Manifold Assembly                    | 1   |
| 6      | 50006-16-C5D | Hex-head Cap Screw, Drilled, 3/8-16 unc x 2"            | 8   |
| 7      | 50806-N-S    | Flat Washer                                             | 8   |
| 8      | 113915       | Hydraulic Tubing Shroud                                 | 1   |
| 9      | 50006-6-C5D  | Hex-head Cap Screw, Drilled, 3/8-16 x 3/4"              | 4   |
| 10     | 118332       | Tube Assembly                                           | 1   |
| 11     | 118333       | Tube Assembly                                           | 1   |
| 12     | 118334       | Tube Assembly                                           | 1   |
| 13     | 114009-2     | Torsion Spring                                          | 1   |
| 14     | 50820-N-C    | Washer, 1 1/4"                                          | 8   |
| 15     | 114007       | Clevis Pin                                              | 1   |
| 16     | 114006       | Spur                                                    | 1   |
| 17     | 115163       | Stop                                                    | 1   |
| 18     | 114008       | Stop Tube                                               | 1   |
| 19     | 51404-24-S   | Cotter Pin                                              | 1   |
| 20     | 51404-28-S   | Cotter Pin                                              | 1   |
| 21     | 50520-C      | Slotted Nut                                             | 1   |
| 22     | 114196       | Cable Assembly                                          | 1   |
| 23     | 114212       | Wire Rope Clip, 5/16"                                   | 2   |
| 24     | 55510-C      | Hex-head Nut, Slotted, 5/8-18                           | 4   |

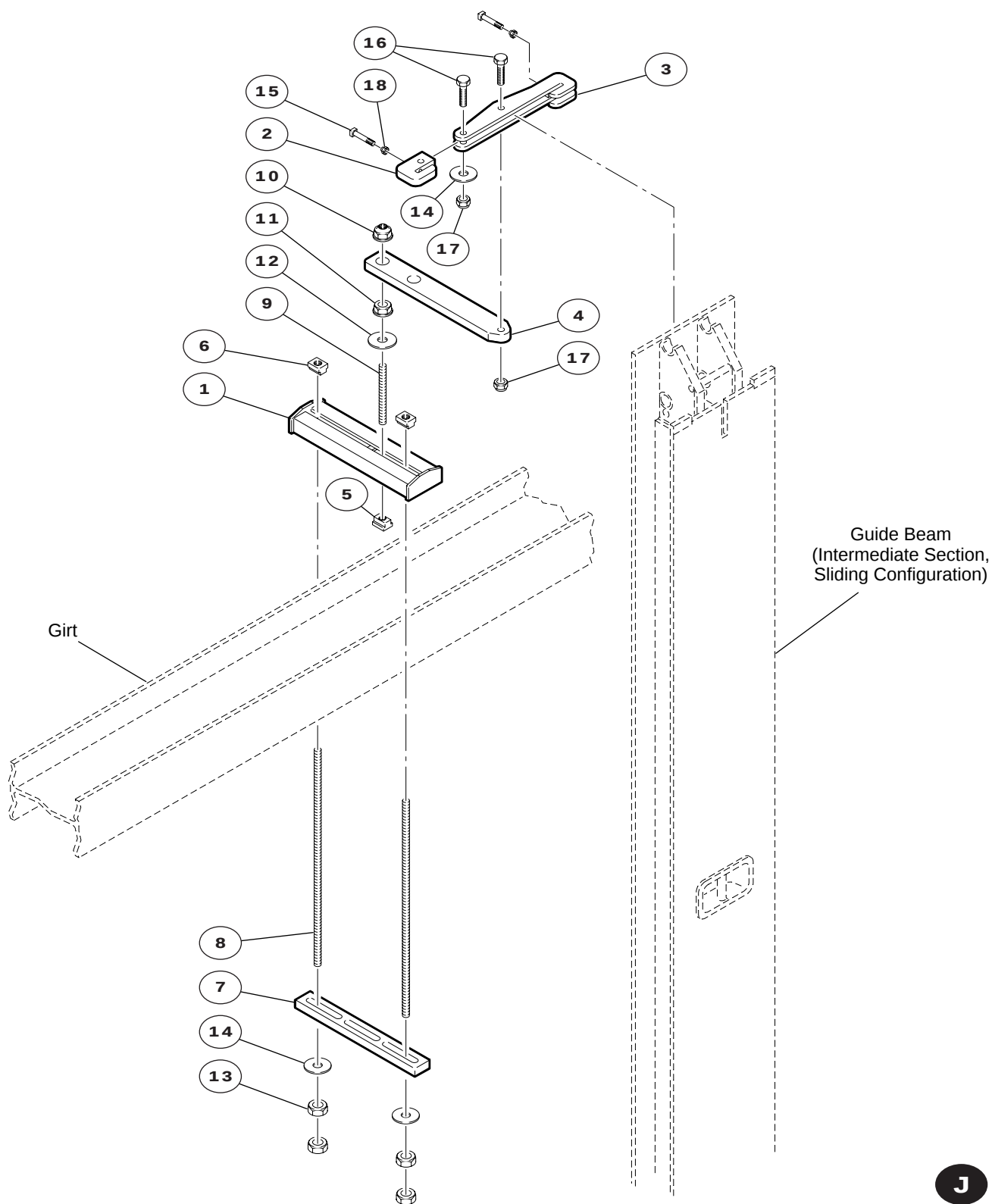
**Key to Figure 5-11. Link tilt hydraulic cylinder assembly (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                         | <b>Qty</b> |
|---------------|---------------|--------------------------------------------|------------|
| 25            | 51435-14      | Cotter Pin                                 | 4          |
| 26            | 115736        | Safety Cover                               | 1          |
| 27            | 50816-N-C     | Hex-head Bolt, .500-13 x 1.00 long         | 3          |
| 28            | 113875        | Hydraulic Cylinder, Double Ended, 4" x 26" | 1          |
| 29            | 103141-10     | Hydraulic Cylinder Clevis                  | 1          |
| 30            | 51604-14-C    | Roll Pin, .250 dia. x 1.75" long           | 1          |
| 31            | 115162        | Stud                                       | 1          |
| 32            | 51604-18-C    | Roll Pin, .250 dia. x 2.25" long           | 1          |
| 33            | 110774        | Manifold Piston, Load Holding              | 1          |
| 34            | 93547-1B30N   | Check Valve, Pilot-to-Open                 | 1          |
| 35            | 94518-13HN    | Counterbalance Valve                       | 1          |
| 36            | 53000-1-S     | Pipe Plug, 1/16 NPT                        | 1          |
| 37            | 93024-4SAE    | Test Fitting, SAE-4                        | 1          |
| 38            | 94042-36      | Orifice, 1/8" NPT x .142 dia.              | 1          |
| 39            | 93018-08      | Orifice, #10-32 UNF x .031 dia.            | 1          |
| 40            | 87196-2-S     | O-Ring Plug                                | 1          |
| 41            | 56529-4-4-S   | O-Ring Connector, BOSS/37", 1/4"           | 2          |
| 42            | 56529-8-4-S   | O-Ring Connector, BOSS/37", 1/2" x 1/4"    | 1          |
| 43            | 55915-8       | Dust Cap, 1/2" dia.                        | 1          |
| 44            | 112809-04     | Shipping Cap, Threaded                     | 3          |
| 45            | 87196-6-S     | O-Ring Plug                                | 1          |
| 46            | 107303-1-12   | Flange Protector, SAE J518                 | 1          |
| 47            | 51300-214-B   | O-Ring                                     | 1          |
| 48            | 55908-4-4-S   | Valved Coupler, QC/DC, Ext. Pipe, 1/4"     | 1          |

***Key to Figure 5-11. Link tilt hydraulic cylinder assembly (continued)***

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                       | <b>Qty</b> |
|---------------|---------------|------------------------------------------|------------|
| 49            | 55913-8-8-S   | Valved Nipple, QC/DC, Ext. Pipe, 1/2"    | 1          |
| 50            | 55912-8-8-S   | Valved Coupler, QC/DC, Ext. Pipe, 1/2"   | 1          |
| 51            | 56564-8-8     | 90° Int. Pipe Elbow, SAE O-Ring 1/2"     | 1          |
| 52            | 56551-6-4-S   | O-Ring Connector, Int. Pipe, 3/8" x 1/4" | 1          |
| 53            | 56702-4-4-C   | 90° Ext. Pipe Elbow, 1/4"                | 1          |
| 54            | 55914-4       | Dust Plug, 1/4" OD                       | 1          |
| 55            | 55914-8       | Dust Plug, 1/2" OD                       | 1          |
| 56            | 99838-1       | Sun Cartridge Cover, Series 1            | 1          |
| 57            | 112471        | Load-Holding Piston Manifold             | 1          |

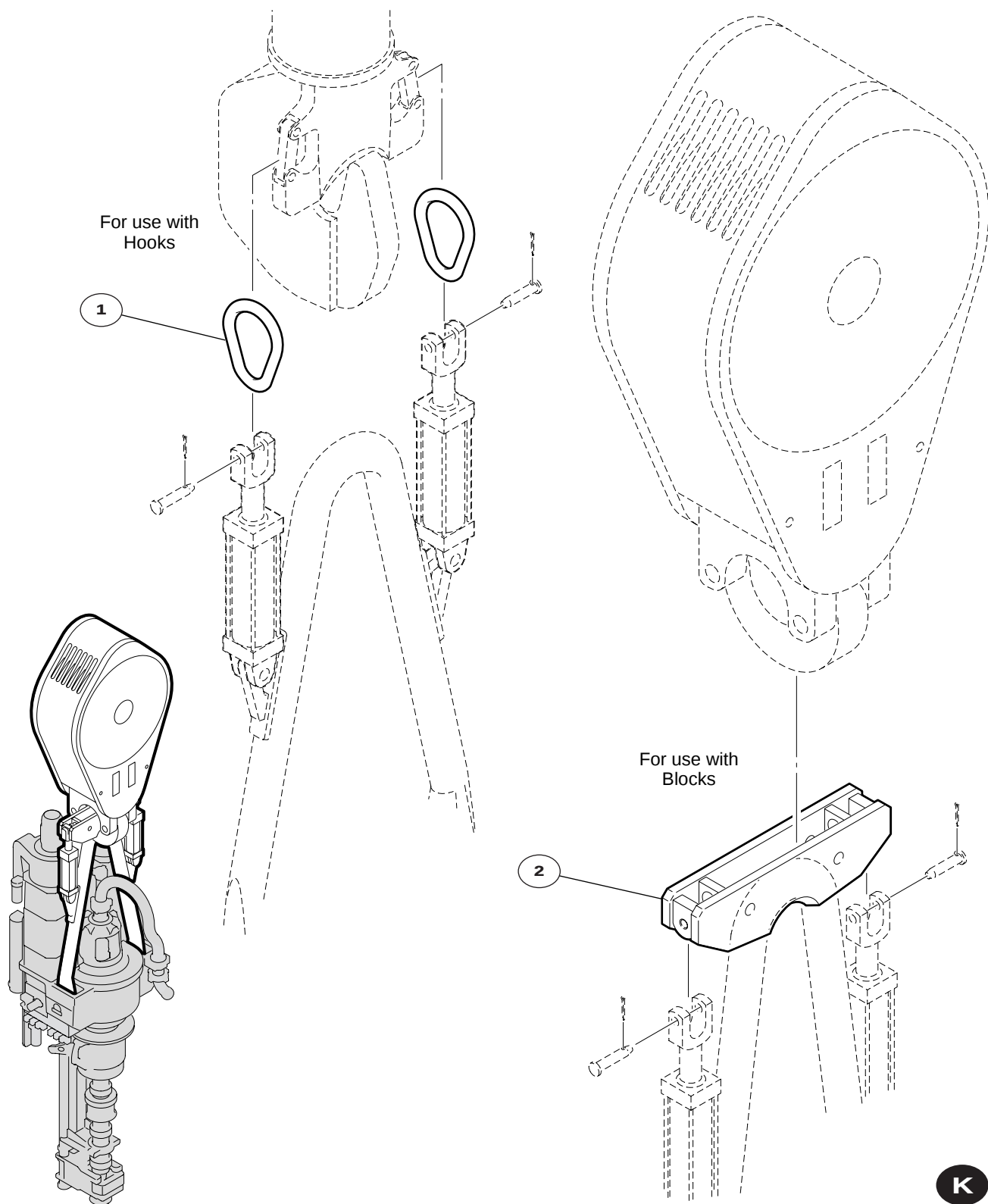




**Figure 5-12. Intermediate tieback kit**

**Key to Figure 5-12. Intermediate tieback kit**

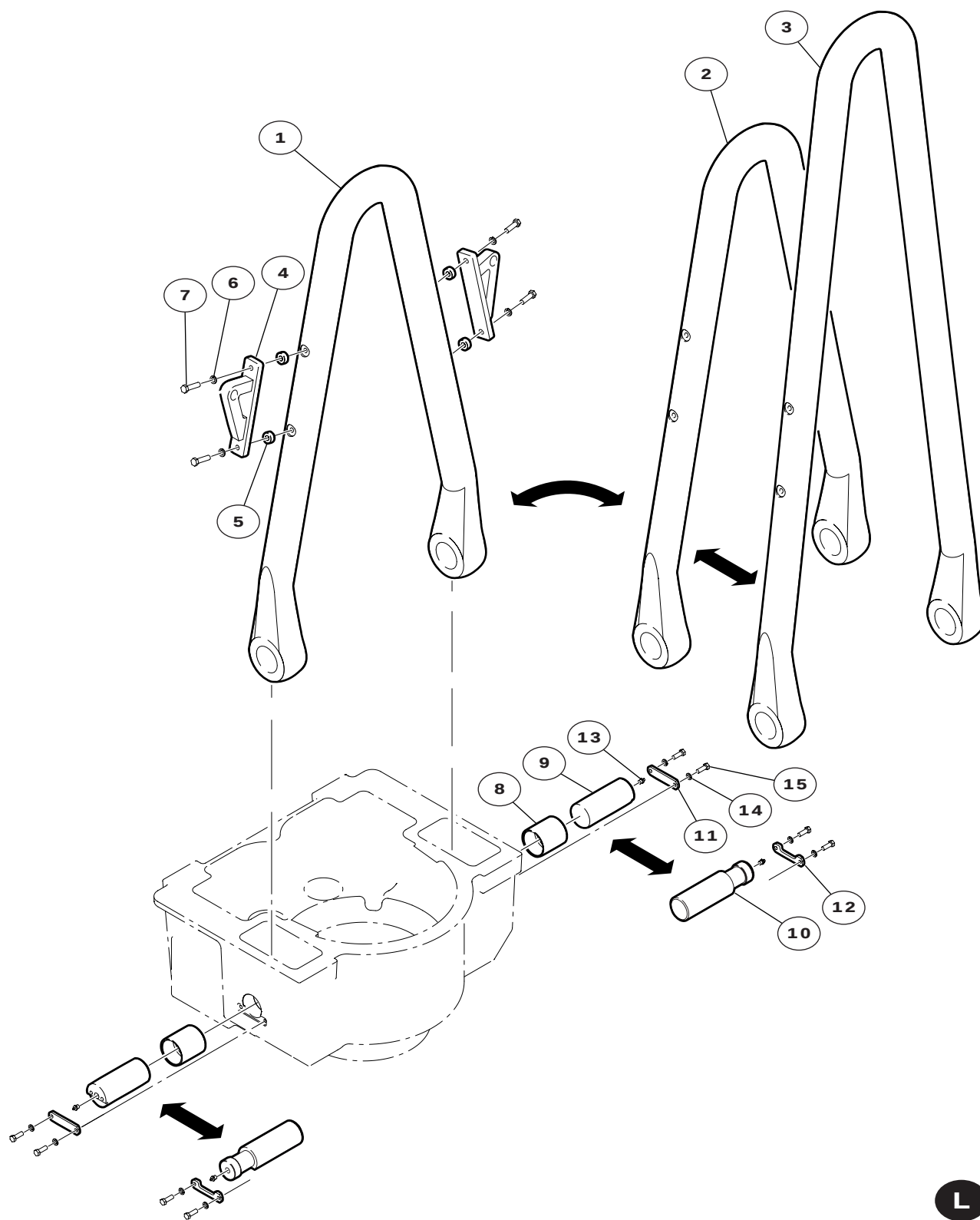
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>               | <b>Qty</b> |
|---------------|---------------|----------------------------------|------------|
| 1             | 118094        | Girt Strap                       | 1          |
| 2             | 118093        | Hook                             | 1          |
| 3             | 118092        | Weldment Strap                   | 1          |
| 4             | 118091        | Link                             | 1          |
| 5             | 118909-1      | T-Slot Nut                       | 1          |
| 6             | 118909-2      | T-Slot Nut                       | 2          |
| 7             | 118116        | Strap                            | 1          |
| 8             | 112893-8      | Threaded Rod, .750-10 x 18" long | 2          |
| 9             | 112893-9      | Threaded Rod, 1.000-8 x 5" long  | 1          |
| 10            | 51816-C       | Self-Locking Hex Nut             | 1          |
| 11            | 118135        | Hex Nut Bushing                  | 1          |
| 12            | 50816-W-C     | Flat Washer, Wide                | 2          |
| 13            | 50212-C       | Hex Nut, Standard                | 4          |
| 14            | 50812-W-C     | Flat Washer, Wide                | 3          |
| 15            | 118134-1      | Square-head Set Screw            | 2          |
| 16            | 50012-30-C5   | Hex-head Cap Screw               | 2          |
| 17            | 51812-C       | Self-Locking Hex Nut             | 2          |
| 18            | 50308-C       | Hex Nut, Jam                     | 2          |



**Figure 5-13. Traveling equipment attachment kit**

***Key to Figure 5-13. Traveling equipment attachment kit***

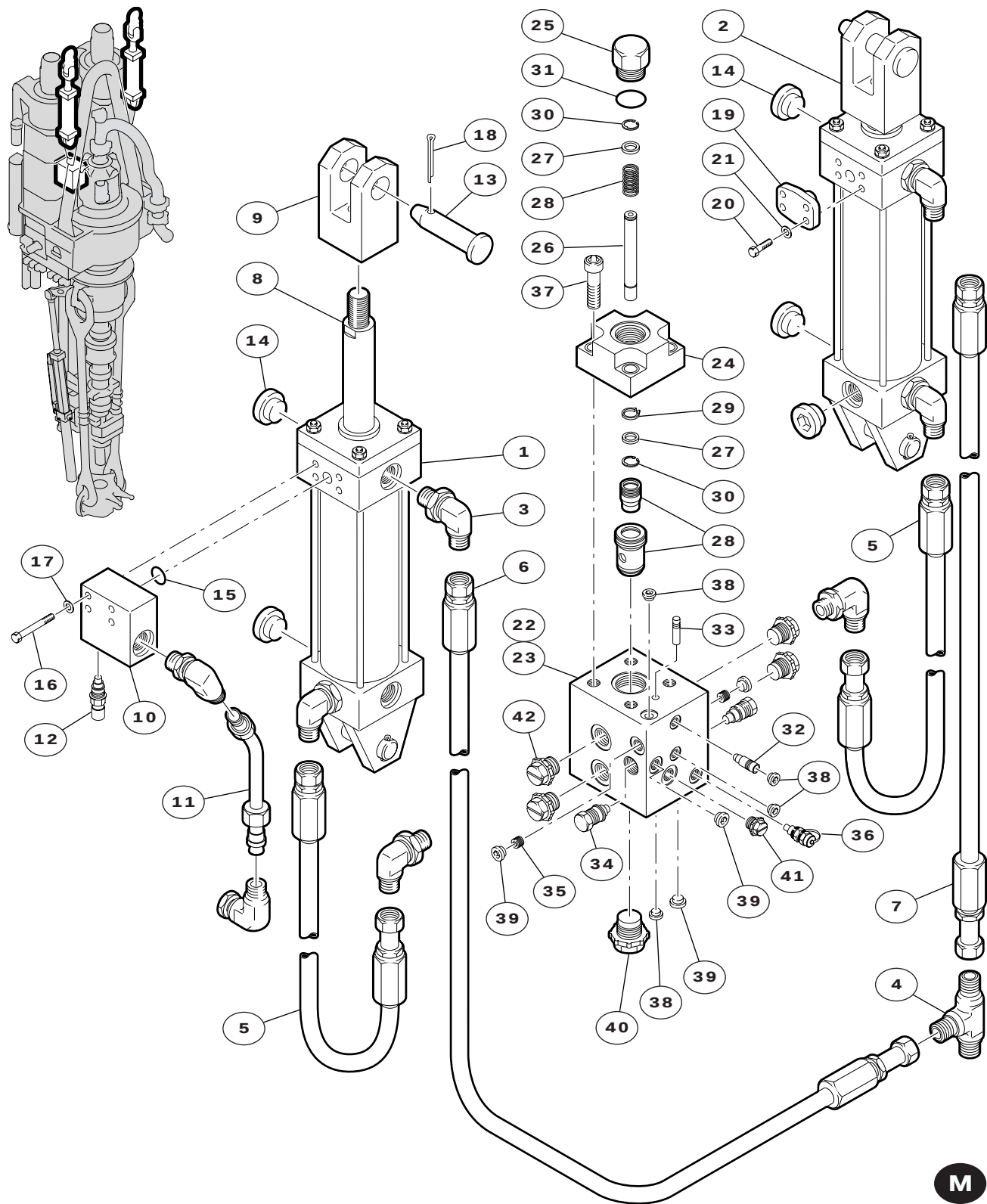
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>  | <b>Qty</b> |
|---------------|---------------|---------------------|------------|
| 1             | 76717         | Pear Link           | 2          |
| 2             | 117076        | Counterbalance Beam | 1          |



**Figure 5-14. Bail assembly**

**Key to Figure 5-14. Bail assembly**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>              | <b>Qty</b> |
|---------------|---------------|---------------------------------|------------|
| 1             | 109505        | 400 Ton Bail, 78.5" long        | 1          |
| 2             | 109505-1      | 400 Ton Bail, 84.0" long        | 1          |
| 3             | 109505-3      | 400 Ton Bail, 120.0" long       | 1          |
| 4             | 110077        | Counterbalance Lug              | 2          |
| 5             | 110070        | Counterbalance Lug Button       | 4          |
| 6             | 50912-C       | Lock Washer, Regular            | 4          |
| 7             | 50012-24-C5D  | Hex-head Cap Screw              | 4          |
| 8             | 109507        | Bail Pin Bushing                | 2          |
| 9             | 109506        | Bail Pin (Carriage)             | 2          |
| 10            | 115123        | Bail Pin (Guide Dolly)          | 2          |
| 11            | 110123        | Bail Pin Retainer (Carriage)    | 2          |
| 12            | 115124        | Bail Pin Retainer (Guide Dolly) | 2          |
| 13            | 53201         | Grease Fitting, .125-27 NPT     | 2          |
| 14            | 50908-C       | Lock Washer, Regular            | 4          |
| 15            | 50008-12-C5D  | Hex-head Cap Screw              | 4          |



**Figure 5-15. Counterbalance assembly**

**Key to Figure 5-15. Counterbalance assembly**

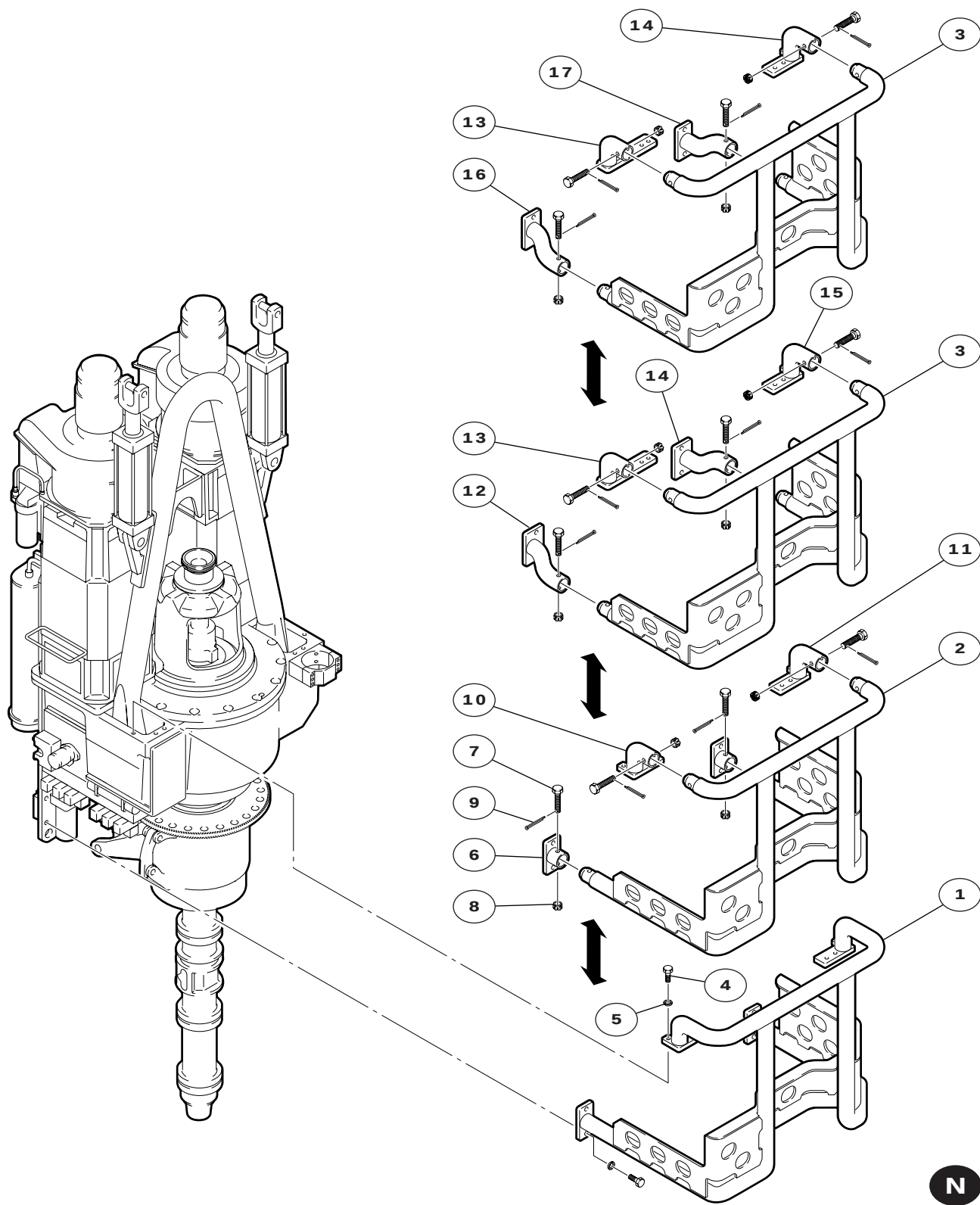
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                             | <b>Qty</b> |
|---------------|---------------|------------------------------------------------|------------|
| 1             | 110703        | Counterbalance Cylinder Assembly               | 1          |
| 2             | 110704        | Counterbalance Cylinder Assembly               | 1          |
| 3             | 56519-12-12-S | O-Ring Elbow, BOSS/37°                         | 8          |
| 4             | 56513-12-S    | Bulkhead Union Tee, 37°                        | 1          |
| 5             | 59143P290122  | High-Pressure Hydraulic Hose Assembly          | 2          |
| 6             | 59124P290129  | High-Pressure Hydraulic Hose Assembly          | 2          |
| 7             | 59144P290135  | High-Pressure Hydraulic Hose Assembly          | 2          |
| 8             | 110687        | Counterbalance Cylinder, 4"                    | 2          |
| 9             | 111935        | Counterbalance Cylinder, Rod End Clevis        | 2          |
| 10            | 110716-2      | Relief Counterbalance Manifold                 | 1          |
| 11            | 111936        | Counterbalance Cylinder Tube                   | 1          |
| 12            | 94522-21N     | Pressure Relief Valve Cartridge, Direct Acting | 1          |
| 13            | 111944        | Counterbalance Cylinder Clevis Pin             | 2          |
| 14            | 87196-12-S    | Hex Socket Plug, SAE-12                        | 5          |
| 15            | 51300-214B    | O-Ring                                         | 1          |
| 16            | 50006-20-C5D  | Hex-head Cap Screw (UNC-2A)                    | 4          |
| 17            | 50806-N-C     | Flat Washer                                    | 4          |
| 18            | 51405-18-S    | Cotter Pin                                     | 2          |
| 19            | 94681-12      | Blind Flange Kit, Code 61                      | 1          |
| 20            | 50006-12-C5D  | Screw                                          | 4          |
| 21            | 50906-C       | Washer                                         | 4          |
| 22            | 111712        | Pre-Fill Valve Assembly                        | 1          |
| 23            | 111707-2      | Valve Body                                     | 2          |
| 24            | 111708        | Modified Cover, 25 mm                          | 1          |



**Key to Figure 5-15. Counterbalance assembly (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                     | <b>Qty</b> |
|---------------|---------------|----------------------------------------|------------|
| 25            | 111709        | Special Plug, SAE J514-12              | 1          |
| 26            | 111710        | Guide Rod                              | 1          |
| 27            | 111711        | Guide Disc                             | 2          |
| 28            | 112825        | Logic Cartridge Insert Valve, Modified | 1          |
| 29            | 53500-68      | Retaining Ring, Internal               | 1          |
| 30            | 53600-40      | Retaining Ring, External               | 2          |
| 31            | 105643-12     | O-Ring, 3-912                          | 1          |
| 32            | 109498-800D   | Lee Jet, 8000 LOHM                     | 1          |
| 33            | 92654         | Check Valve, .187 dia.                 | 1          |
| 34            | 94536-175N    | Check Valve, T-13A, 75 psid            | 2          |
| 35            | 93019-19      | Orifice Plug, .25-28 x .075 dia.       | 2          |
| 36            | 93024-4SAE    | Test Fitting, SAE-4                    | 1          |
| 37            | 50108-14-BD   | Socket Cap Screw, .50-13 x 1.75        | 4          |
| 38            | 87196-2-S     | Hex Socket Plug, SAE J514-2            | 4          |
| 39            | 87196-4-S     | Hex Socket Plug, SAE J514-4            | 4          |
| 40            | 108465-16     | Plastic Plug, SAE-16                   | 1          |
| 41            | 108465-06     | Plastic Plug, SAE-6                    | 1          |
| 42            | 108465-12     | Plastic Plug, SAE-12                   | 4          |

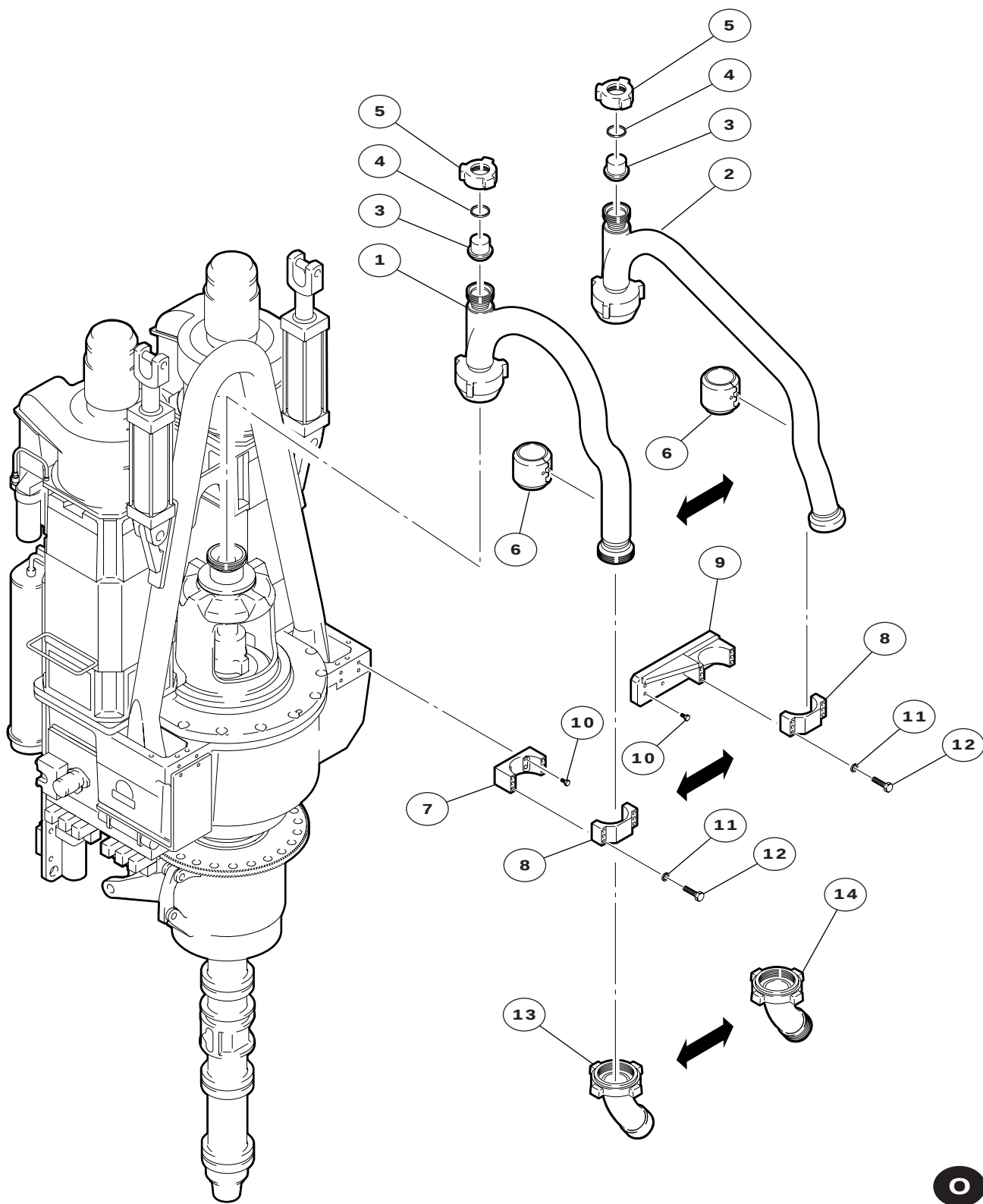




**Figure 5-16. Motor guards**

**Key to Figure 5-16. Motor guards**

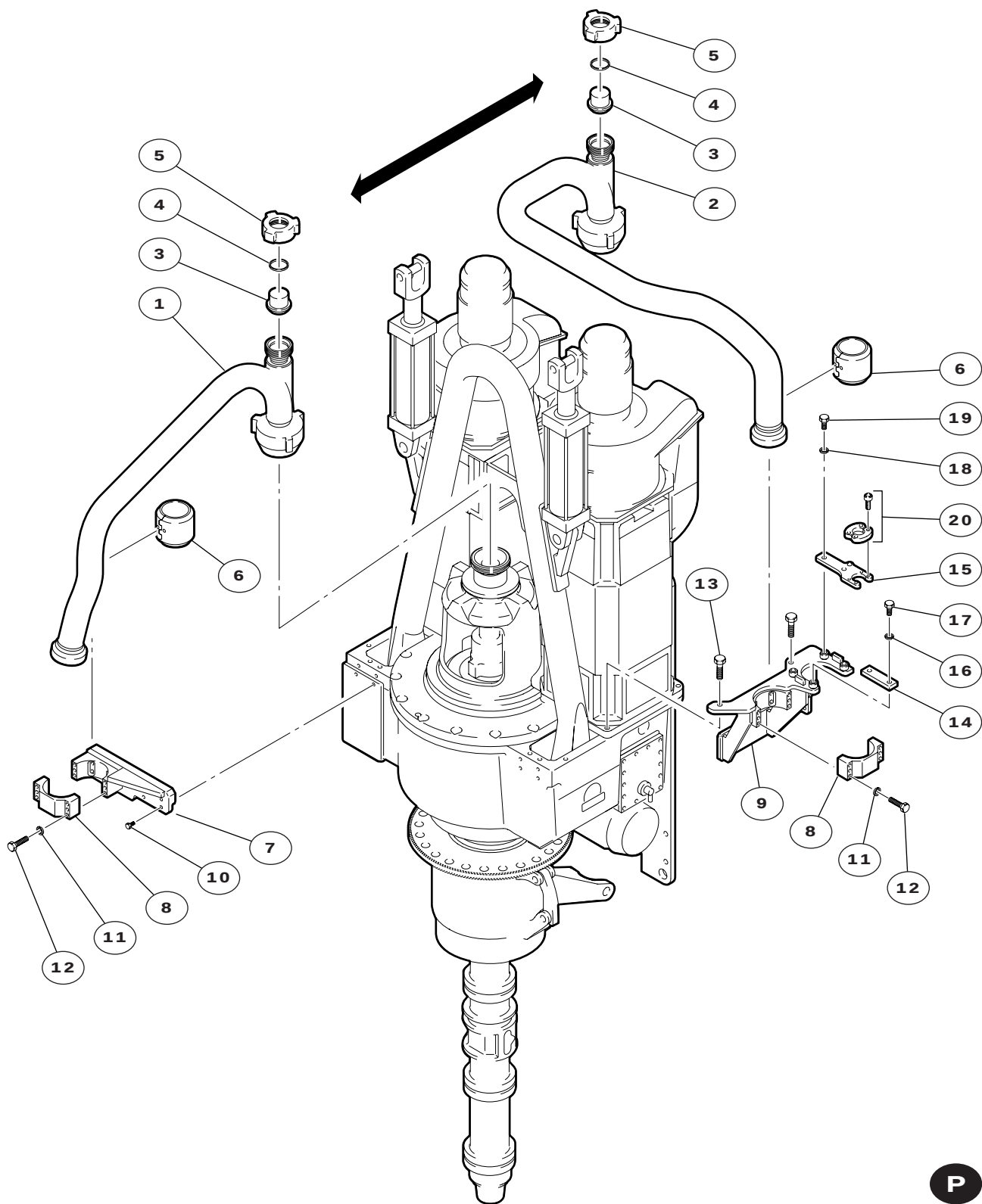
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                      | <b>Qty</b> |
|---------------|---------------|-----------------------------------------|------------|
| 1             | 110006        | Motor Housing Guard                     | 1          |
| 2             | 120917        | Motor Housing Guard Package             | 1          |
| 3             | 121808        | Motor Housing Guard Package (UK Rental) | 1          |
| 4             | 50012-24-C5D  | Hex-head Cap Screw                      | 16         |
| 5             | 50912-C       | Lock Washer, Regular                    | 56         |
| 6             | 117089        | Lower Support                           | 2          |
| 7             | 50012-30-C5   | Hex-head Cap Screw                      | 4          |
| 8             | 50512-C       | Hex Nut, Slotted                        | 4          |
| 9             | 51402-12      | Cotter Pin, 1/8 NOM                     | 4          |
| 10            | 117088-BCS    | Upper Support, Left-hand                | 1          |
| 11            | 117088-500    | Upper Support, Right-hand               | 1          |
| 12            | 121806        | Lower Support, Left-hand (UK Rental)    | 1          |
| 13            | 121762        | Upper Support, Left-hand (UK Rental)    | 1          |
| 14            | 121807        | Lower Support, Right-hand (UK Rental)   | 1          |
| 15            | 117088-500    | Upper Support, Right-hand (UK Rental)   | 1          |
| 16            | 121762        | Upper Support, Left-hand (EEx)          | 1          |
| 17            | 121743        | Lower Support, Right-hand (EEx)         | 1          |



**Figure 5-17. S-pipe**

***Key to Figure 5-17. S-pipe***

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                          | <b>Qty</b> |
|---------------|---------------|---------------------------------------------|------------|
| 1             | 108754        | S-Pipe Weldment, Right-hand (inside guard)  | 1          |
| 2             |               | S-Pipe Weldment, Right-hand (outside guard) | 1          |
| 3             | 91921         | Blind Plug, 3" 1002 Hammer Union            | 1          |
| 4             | 91923         | Lip Seal Ring, 3" 1002 Hammer Union (RP)    | 1          |
| 5             | 91924         | Nut, 3" Hammer Union                        | 1          |
| 6             | 92426         | S-Pipe Rubber                               | 1          |
| 7             | 108870-1      | S-Pipe Mount, Base                          | 1          |
| 8             | 108870-2      | S-Pipe Mount, Top                           | 1          |
| 9             | 117061        | S-Pipe Mount, Right-hand                    | 1          |
| 10            | 50110-14-CD   | Socket-head Cap Screw                       | 4          |
| 11            | 50908-C       | Lock Washer, Regular                        | 6          |
| 12            | 50008-30-C5D  | Hex-head Cap Screw                          | 6          |
| 13            | 81153         | S-Pipe Elbow, 4" API Female Pipe Thread     | 1          |
| 14            | 84617-501     | S-Pipe Elbow, 4" 1002 Hammer Union          | 1          |

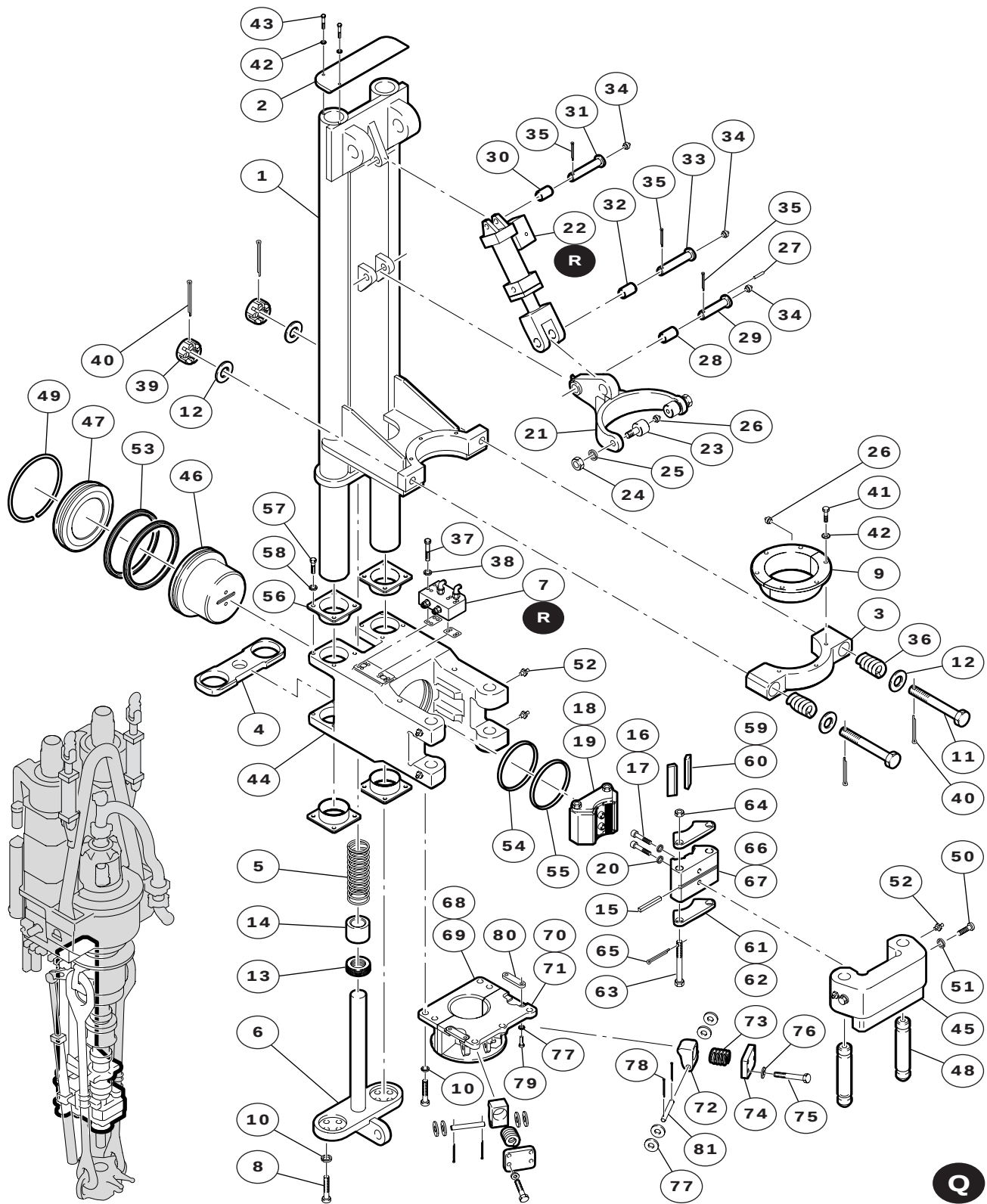


**Figure 5-18. S-pipe (Hercules)**

**Key to Figure 5-18. S-pipe (Hercules)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                         | <b>Qty</b> |
|---------------|---------------|--------------------------------------------|------------|
| 1             |               | S-Pipe Weldment, Left-hand (outside guard) | 1          |
| 2             | 116376        | S-Pipe Weldment (Hercules)                 | 1          |
| 3             | 91921         | Blind Plug, 3" 1002 Hammer Union           | 1          |
| 4             | 91923         | Lip Seal Ring, 3" 1002 Hammer Union (RP)   | 1          |
| 5             | 91924         | Nut, 3" Hammer Union                       | 1          |
| 6             | 92426         | S-Pipe Rubber                              | 1          |
| 7             | 114840        | S-Pipe Mount, Left-hand (outside of guard) | 1          |
| 8             | 108870-2      | S-Pipe Mount, Top                          | 1          |
| 9             | 116411        | S-Pipe Service Loop Bracket                | 1          |
| 10            | 50110-14-CD   | Socket-head Cap Screw                      | 4          |
| 11            | 50908-C       | Lock Washer, Regular                       | 6          |
| 12            | 50008-30-C5D  | Hex-head Cap Screw                         | 6          |
| 13            | 50012-13-C5D  | Hex-head Cap Screw                         | 2          |
| 14            | 78002         | Service Loop Bracket Clamp                 | 1          |
| 15            | 107714        | Composite Cable Mount                      | 1          |
| 16            | 50912-C       | Lock Washer, Regular                       | 6          |
| 17            | 50012-16-C5D  | Hex-head Cap Screw                         | 4          |
| 18            | 50908-C       | Lock Washer, Regular                       | 4          |
| 19            | 50008-16-C5D  | Hex-head Screw                             | 4          |





**Figure 5-19. Torque arrestor assembly**

**Key to Figure 5-19. Torque arrestor assembly**

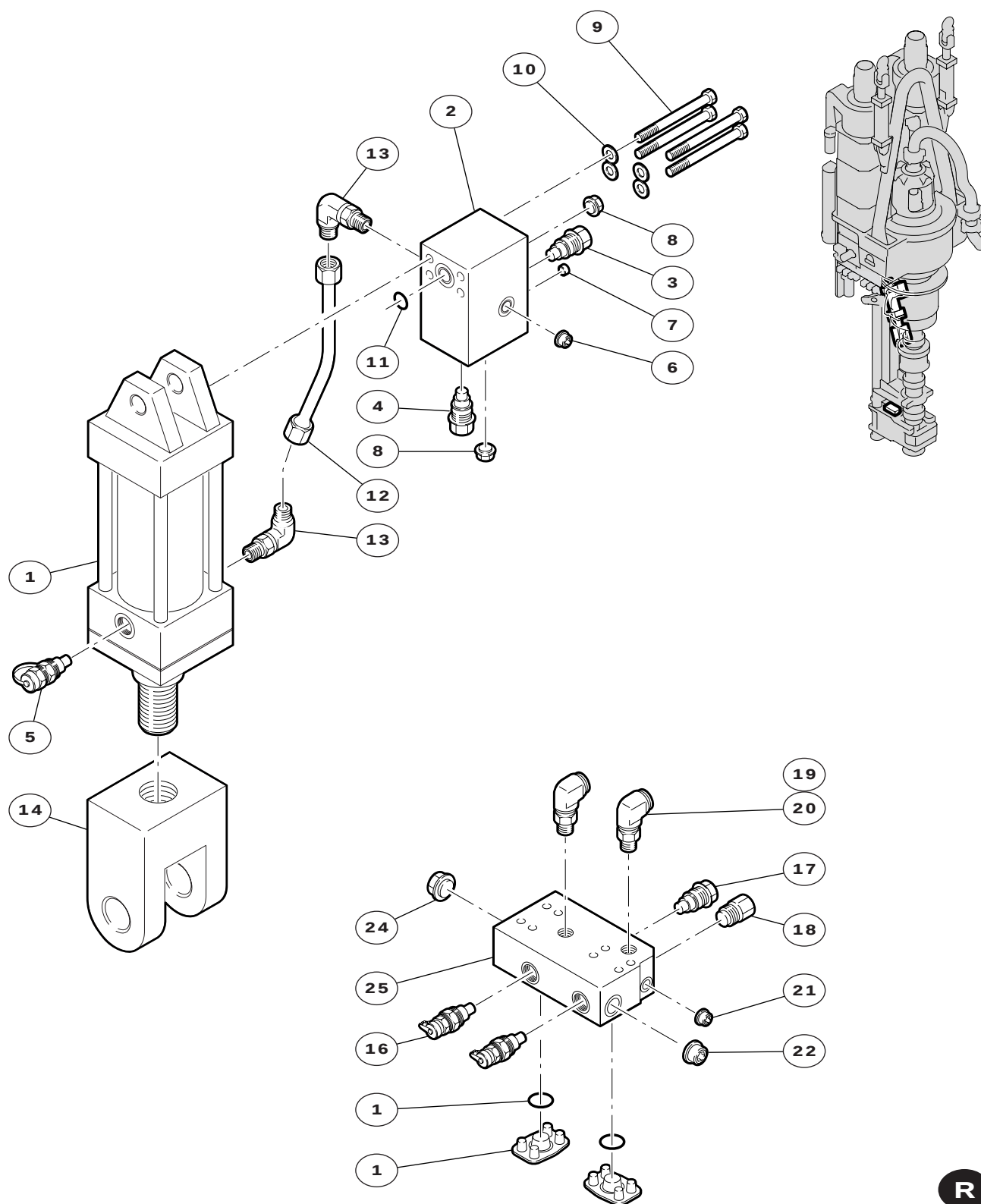
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                    | <b>Qty</b> |
|---------------|---------------|---------------------------------------|------------|
| 1             | 110051        | Torque Arrestor                       | 1          |
| 2             | 120158        | Torque Arrestor Stop, PH-50           | 1          |
| 3             | 110093        | Outer Collar                          | 1          |
| 4             | 110095        | Spring Retainer                       | 1          |
| 5             | 110083        | Spring                                | 1          |
| 6             | 110052        | End Cap                               | 1          |
| 7             | 117819        | Manifold Assembly, Clamp Regeneration | 1          |
| 8             | 50012-16-C5D  | Hex-head Cap Screw, Drilled           | 15         |
| 9             | 110092        | Wear Ring                             | 1          |
| 10            | 50912-C       | Lock Washer                           | 15         |
| 11            | 79346         | Hex-head Cap Screw, Drilled Shank     | 2          |
| 12            | 79178         | Flat Washer                           | 4          |
| 13            | 110087        | Spring Spacer                         | 2          |
| 14            | 110086        | Spring Sleeve                         | 1          |
| 15            | 16532         | Key                                   | 2          |
| 16            | 50108-18-C    | Socket-head Cap Screw                 | 4          |
| 17            | 50108-16-C    | Socket-head Cap Screw                 | 4          |
| 18            | 80492         | Jaw Assembly, 4.0-5.0 OD              | 2          |
| 19            | 85786-2       | Jaw Assembly, 5.5-6.5 OD              | 2          |
| 20            | 51108-C       | Hi-Collar Washer                      | 4          |
| 21            | 110073        | IBOP Actuator Yoke                    | 1          |
| 22            | 110186        | IBOP Actuator Cylinder Assembly       | 1          |
| 23            | 71847         | Roller                                | 2          |
| 24            | 55214-C       | Hex Nut, 7/8-14                       | 2          |

**Key to Figure 5-19. Torque arrestor assembly (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                  | <b>Qty</b> |
|---------------|---------------|-------------------------------------|------------|
| 25            | 50914-C       | Lock Washer                         | 2          |
| 26            | 53208         | Grease Fitting                      | 6          |
| 27            | 51606-06-C    | Roll Pin                            | 1          |
| 28            | 110178        | Bronze Bearing                      | 1          |
| 29            | 110180        | Pivot Pin                           | 1          |
| 30            | 110177        | Bronze Bearing                      | 1          |
| 31            | 110074        | Pivot Pin                           | 1          |
| 32            | 110179        | Bronze Bearing                      | 1          |
| 33            | 110075        | Pivot Pin                           | 1          |
| 34            | 53209         | Grease Fitting                      | 3          |
| 35            | 51403-16      | Cotter Pin                          | 3          |
| 36            | 79179         | Die Spring                          | 2          |
| 37            | 50005-20-C5D  | Hex-head Cap Screw, Drilled         | 8          |
| 38            | 50905-C       | Lock Washer                         | 8          |
| 39            | 50516-2       | Hex Nut, Slotted, 1"-8              | 2          |
| 40            | 51403-14      | Cotter Pin, 3/16 x 1 3/4"           | 2          |
| 41            | 50008-10-2D   | Hex-head Cap Screw, 1/2-13 x 1 1/4" | 6          |
| 42            | 51008-C       | Lock Washer, Heavy, 1/2"            | 8          |
| 43            | 50008-14-C5D  | Hex-head Cap Screw                  | 2          |
| 44            | 112929        | Clamp Cylinder Body                 | 1          |
| 45            | 110108        | Gate                                | 1          |
| 46            | 12820         | Piston                              | 1          |
| 47            | 11075         | Cylinder Head                       | 1          |
| 48            | 76532         | Hinge Pin                           | 2          |
| 49            | 11085         | Cylinder Head Ring                  | 1          |
| 50            | 97560         | Hex-head Cap Screw, Modified        | 2          |
| 51            | 50912-C       | Lock Washer, 3/4"                   | 2          |
| 52            | 53201         | Grease Fitting                      | 6          |
| 53            | 72219         | Piston Seal                         | 2          |
| 54            | 72220         | Rod Seal                            | 1          |

**Key to Figure 5-19. Torque arrestor assembly (continued)**

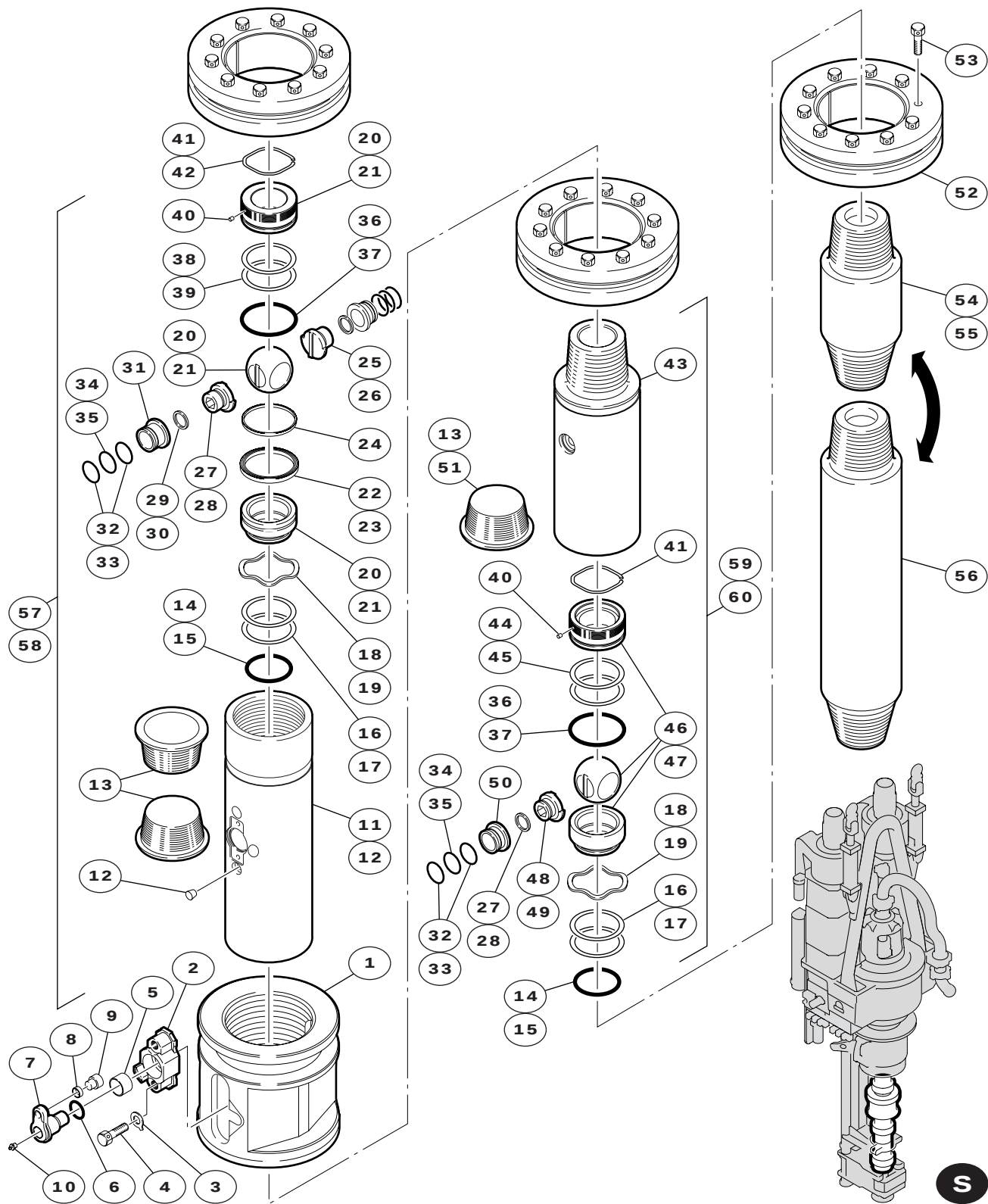
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                   | <b>Qty</b> |
|---------------|---------------|--------------------------------------|------------|
| 55            | 72221         | Wiper Rod                            | 1          |
| 56            | 110152        | Wear Bushing, SST                    | 4          |
| 57            | 50008-8-C5D   | Hex-head Screw, 1/2-13 UNC x 1" long | 16         |
| 58            | 50908-C       | Lock Washer, 1/2"                    | 16         |
| 59            | 16401-2       | Tong Die                             | 2          |
| 60            | 16781         | Tong Die                             | 2          |
| 61            | 76406         | Retainer Die                         | 2          |
| 62            | 78051         | Retainer Die                         | 2          |
| 63            | 76444-2       | Retainer Bolt                        | 2          |
| 64            | 50514-C       | Hex-head Nut                         | 2          |
| 65            | 51435-16-S    | Cotter Pin                           | 2          |
| 66            | 733342-3      | Jaw                                  | 1          |
| 67            | 79859         | Jaw                                  | 1          |
| 68            | 112151        | Stabbing Guide Clamp Cylinder        | 1          |
| 69            | 112927        | Stabbing Guide                       | 1          |
| 70            | 112152        | Stabbing Guide Gate                  | 1          |
| 71            | 112928        | Stabbing Guide                       | 1          |
| 72            | 76442         | Arm Guide                            | 2          |
| 73            | 76443         | Spring                               | 2          |
| 74            | 76445         | Retainer                             | 2          |
| 75            | 50008-13-C5D  | Hex-head Cap Screw, Drilled          | 8          |
| 76            | 50810-N-C     | Flat Washer, Narrow                  | 8          |
| 77            | 50908-C       | Lock Washer, Regular Series          | 10         |
| 78            | 51402-8-S     | Cotter Pin                           | 4          |
| 79            | 50008-7-C5D   | Hex-head Cap Screw, 1/2"             | 2          |
| 80            | 112883        | Hinge Pin Retainer                   | 2          |
| 81            | 76398         | Pin                                  | 2          |



**Figure 5-20. IBOP actuator**

**Key to Figure 5-20. IBOP actuator**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                 | <b>Qty</b> |
|---------------|---------------|------------------------------------|------------|
| 1             | 11072         | Hydraulic Cylinder                 | 1          |
| 2             | 110187-2      | IBOP Manifold, Regen               | 1          |
| 3             | 93548-1S30N   | Check Valve Cartridge              | 1          |
| 4             | 94534-1CXN    | Logic Cartridge                    | 1          |
| 5             | 93024-6SAE    | Test Fitting                       | 1          |
| 6             | 87196-6-S     | Hex Socket Plug, SAE-6             | 1          |
| 7             | 53000-1-S     | Hex Socket Plug, 1/16" NPT         | 1          |
| 8             | 108465-06     | Plastic Plug, SAE-6                | 2          |
| 9             | 50005-28-C5D  | Hex-head Cap Screw, 5/16-18 x 3.50 | 4          |
| 10            | 50805-N-S     | Flat Washer, 5/16                  | 4          |
| 11            | 51300-210-B   | O-Ring                             | 1          |
| 12            | 111932        | Tube Assembly, 3/8 OD              | 1          |
| 13            | 56519-6-6-S   | O-Ring Elbow, BOSS/37", 3/8        | 2          |
| 14            | 10341-10      | Rod Clevis                         | 1          |
| 15            | 112489-2      | Clamp Cylinder Manifold            | 1          |
| 16            | 93024-4SAE    | Test Fitting, SAE-4                | 2          |
| 17            | 94537-130N    | Check Cartridge, Pilot-to-Close    | 1          |
| 18            | 109302        | Flow Control Cartridge             | 1          |
| 19            | 56564-8-8-S   | O-Ring Elbow, BOSS/Int. Pipe       | 2          |
| 20            | 53410         | Pipe Closure Plug                  | 2          |
| 21            | 87196-2-S     | Hex Socket Plug, SAE-2             | 1          |
| 22            | 87196-6-S     | Hex Socket Plug, SAE-6             | 1          |
| 23            | 87196-8-S     | Hex Socket Plug, SAE-8             | 1          |
| 24            | 107303-1-8    | Flange Protector, SAE J518         | 2          |
| 25            | 51300-210-B   | O-Ring, Size 210                   | 2          |



**Figure 5-21. IBOP pipehandler**

**Key to Figure 5-21. IBOP pipehandler**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                     | <b>Qty</b> |
|---------------|---------------|----------------------------------------|------------|
| 1             | 110042        | IBOP Actuator Shell                    | 1          |
| 2             | 98897         | Crank Housing (Machining)              | 1          |
| 3             | 107052        | Lock Tab                               | 4          |
| 4             | 50008-14-C5D  | Hex-head Cap Screw, 1/2-13 x 1 3/4"    | 4          |
| 5             | 79825         | Roller Bearing                         | 1          |
| 6             | 51300-220-B   | O-Ring                                 | 1          |
| 7             | 98899         | Crank Arm (Machining)                  | 1          |
| 8             | 99168         | Spacer                                 | 1          |
| 9             | 79824         | Cam Follower                           | 1          |
| 10            | 53201         | Grease Fitting, Straight (.125-17 NPT) | 1          |
| 11            | 110102        | IBOP Body                              | 1          |
| 12            | 91137-10      | Pressure Plug                          | 1          |
| 13            | 77369-5       | Thread Protector, 6 5/8"               | 2          |
| 14            | 89141-3       | O-Ring                                 | 1          |
| 15            | 89453-3       | O-Ring                                 | 1          |
| 16            | 89141-13      | Back-up Ring                           | 1          |
| 17            | 89453-13      | Back-up Ring                           | 2          |
| 18            | 89141-9       | Wave Spring                            | 1          |
| 19            | 89453-9       | Wave Spring                            | 1          |
| 20            | 99500         | Seat/Ball Set                          | 1          |
| 21            | 98966         | Seat/Ball Set                          | 1          |
| 22            | 96439         | U-Cup Seal                             | 1          |
| 23            | 96439-1       | U-Cup Seal                             | 1          |
| 24            | 96438         | Seal Ring Stabilizer                   | 1          |

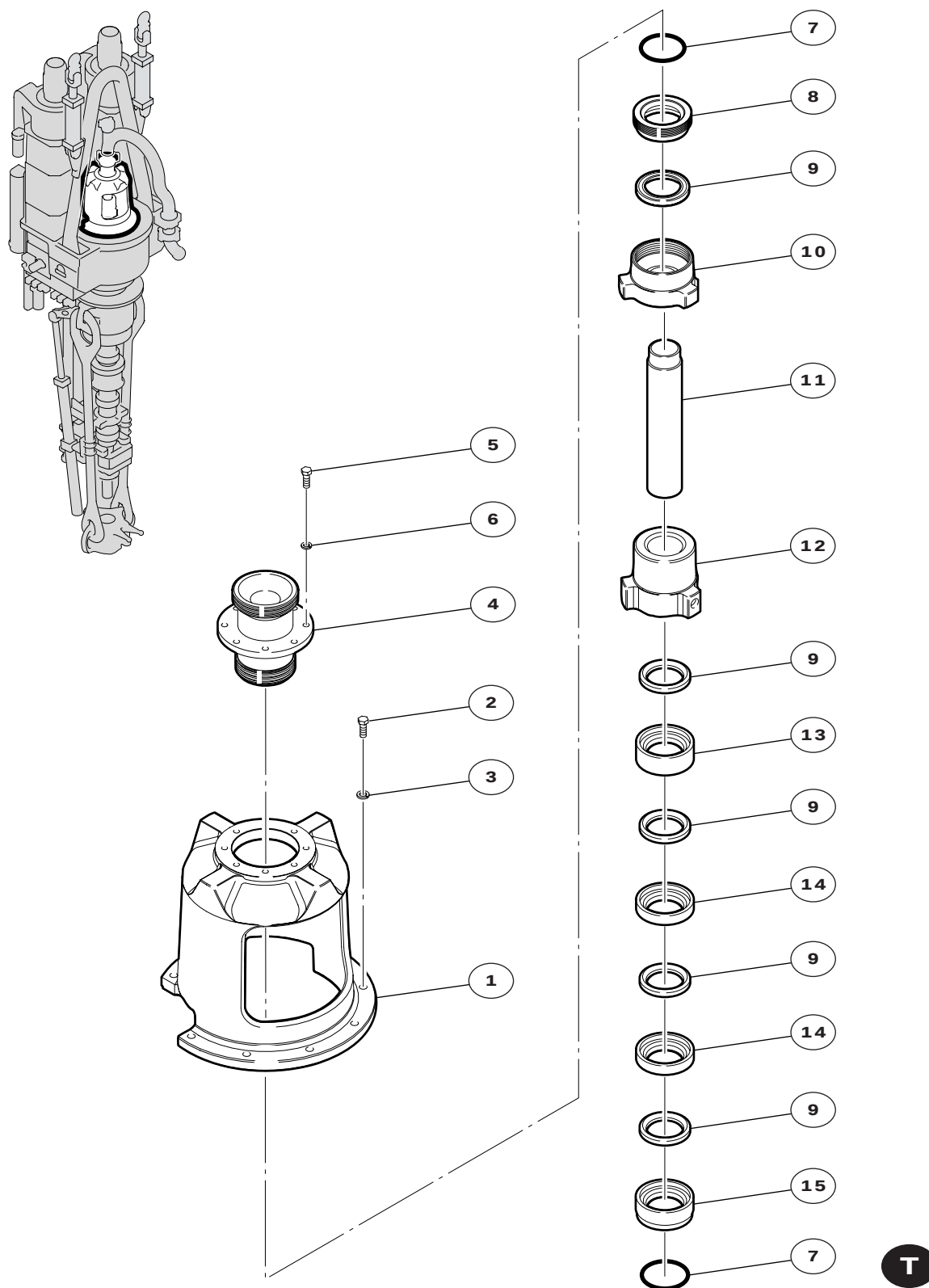


**Key to Figure 5-21. IBOP pipehandler (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>         | <b>Qty</b> |
|---------------|---------------|----------------------------|------------|
| 25            | 110118        | Operator Crank, Right-hand | 1          |
| 26            | 114902        | Operator Crank, Right-hand | 1          |
| 27            | 110128        | Operator Crank, Left-hand  | 1          |
| 28            | 114901        | Operator Crank, Left-hand  | 1          |
| 29            | 89141-8       | Crown Seal                 | 2          |
| 30            | 89453-8       | Crown Seal                 | 2          |
| 31            | 98895         | Crank Sleeve               | 2          |
| 32            | 89141-12      | Back-up Ring               | 4          |
| 33            | 89453-12      | Back-up Ring               | 4          |
| 34            | 89141-11      | O-Ring                     | 2          |
| 35            | 89453-11      | O-Ring                     | 2          |
| 36            | 90441-9       | O-Ring                     | 1          |
| 37            | 89453-16      | O-Ring                     | 1          |
| 38            | 90441-10      | Back-up Ring               | 2          |
| 39            | 89453-17      | Back-up Ring               | 2          |
| 40            | 91137-12      | Nylon Plug                 | 2          |
| 41            | 89141-1       | Retaining Ring             | 1          |
| 42            | 89453-1       | Retaining Ring (H2S)       | 1          |
| 43            | 114705        | IBOP Body, 5 1/4 Short     | 1          |
| 44            | 90441-10      | Back-up Ring               | 2          |
| 45            | 89453-17      | Back-up Ring               | 2          |
| 46            | 99497         | Seat/Ball Set              | 1          |
| 47            | 99501         | Seat/Ball Set (H2S)        | 1          |
| 48            | 89141-7       | Operator Crank, Right-hand | 1          |

**Key to Figure 5-21. IBOP pipehandler (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>             | <b>Qty</b> |
|---------------|---------------|--------------------------------|------------|
| 49            | 89453-7       | Operator Crank, Right-hand     | 1          |
| 50            | 90441-7       | Crank Sleeve                   | 1          |
| 51            | 77369-6       | Thread Protector, Pin          | 1          |
| 52            | 111924        | Shrink Disk Tool Joint Lock    | 1          |
| 53            | 115757        | Hex-head Cap Screw (metric)    | 10         |
| 54            | 76666-4       | Saver Sub (6 5/8 x NC50)       | 1          |
| 55            | 78656-3       | Saver Sub (6 5/8 x NC46)       | 1          |
| 56            | 117625        | Saver Sub (6 5/8 x NC50) Long  | 1          |
| 57            | 110103-500    | Upper IBOP, 6 5/8 x 6 5/8      | 1          |
| 58            | 110103-502    | Upper IBOP, H2S, 6 5/8 x 6 5/8 | 1          |
| 59            | 114706-500    | Lower IBOP, 6 5/8 x 6 5/8      | 1          |
| 60            | 114706-502    | Lower IBOP, H2S, 6 5/8 x 6 5/8 | 1          |



**Figure 5-22. Bonnet/bearing retainer assembly**

**Key to Figure 5-22. Bonnet/bearing retainer assembly**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>         | <b>Qty</b> |
|---------------|---------------|----------------------------|------------|
| 1             | 109531        | Bonnet (Machining)         | 1          |
| 2             | 50012-26-C5D  | Hex-head Cap Screw         | 9          |
| 3             | 50912-C       | Lock Washer, Regular       | 9          |
| 4             | 109523        | S-Pipe Adaptor             | 1          |
| 5             | 50010-14-C5D  | Hex-head Cap Screw, UNC-2A | 8          |
| 6             | 50910-C       | Lock Washer, Regular       | 8          |
| 7             | 91249-12      | O-Ring                     | 2          |
| 8             | 91249-6       | Holding Ring               | 1          |
| 9             | 91249-4       | Packing Set (5 rings)      | 1          |
| 10            | 91249-7       | Holding Nut                | 1          |
| 11            | 91249-10      | Wash Pipe (7,500 psi)      | 1          |
| 12            | 91249-3       | Packing Box Assembly       | 1          |
| 13            | 91249-2       | Spacer Assembly            | 1          |
| 14            | 91249-8       | Middle Spacer              | 2          |
| 15            | 91249-9       | Lower Spacer               | 1          |



**Figure 5-23. Transmission/gearbox assembly**

**Key to Figure 5-23. Transmission/gearbox assembly**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                         | <b>Qty</b> |
|---------------|---------------|--------------------------------------------|------------|
| 1             | 110124        | Main Body, 400 Ton                         | 1          |
| 2             | 109593        | Bearing Retainer                           | 1          |
| 3             | 51212-16      | Dowel Pin                                  | 2          |
| 4             | 50012-28-C5D  | Hex-head Cap Screw                         | 12         |
| 5             | 50912-C       | Lock Washer, Regular                       | 18         |
| 6             | 51300-223-F   | Main Body/Oil Gallery O-Ring               | 2          |
| 7             | 110008        | Main Body/Cover O-Ring                     | 1          |
| 8             | 51217-18      | Bearing Lock Washer                        | 2          |
| 9             | 51218-18      | Internal Retainer Lock Nut                 | 2          |
| 10            | 109501        | Spherical Roller Bearing, Compound Lower   | 2          |
| 11            | 109538        | Retaining Ring                             | 2          |
| 12            | 109539        | Ring Spacer                                | 2          |
| 13            | 109503        | Compound Gear                              | 2          |
| 14            | 96648-1       | Retaining Ring                             | 2          |
| 15            | 109522        | Cylindrical Roller Bearing, Compound Upper | 2          |
| 16            | 91250-1       | Oil Seal                                   | 1          |
| 17            | 91829-1       | Stem Sleeve                                | 1          |
| 18            | 109519        | Tapper Roller Bearing                      | 1          |
| 19            | 110039        | Dowel Pin                                  | 1          |
| 20            | 50016-28-C5D  | Hex-head Cap Screw                         | 10         |
| 21            | 50916-C       | Lock Washer, Regular                       | 10         |
| 22            | 109512        | Bull Gear                                  | 1          |
| 23            | 109514        | Stem/Main Shaft                            | 1          |
| 24            | 108319        | Taper Roller Bearing, Thrust               | 1          |

**Key to Figure 5-23. Transmission/gearbox assembly (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                              | <b>Qty</b> |
|---------------|---------------|-------------------------------------------------|------------|
| 25            | 110040        | Main Shaft Sleeve                               | 1          |
| 26            | 109521        | Cylindrical Roller Bearing, Main Lower          | 1          |
| 27            | 77039-1       | Seal                                            | 2          |
| 28            | 109591        | Wear Sleeve                                     | 1          |
| 29            | 110124        | Main Body, 400 Ton                              | 1          |
| 30            | 109586-5      | Bearing Retainer Shim                           | A/R        |
| 31            | 109586-4      | Bearing Retainer Shim                           | A/R        |
| 32            | 109586-3      | Bearing Retainer Shim                           | A/R        |
| 33            | 109586-2      | Bearing Retainer Shim                           | A/R        |
| 34            | 109586-1      | Bearing Retainer Shim                           | A/R        |
| 35            | 51300-016-B   | Oil Lube Tube O-Ring                            | 2          |
| 36            | 109566        | Upper Bearing Lube Tube                         | 1          |
| 37            | 118668        | Bearing Retainer, Upper Stem                    | 1          |
| 38            | 6581          | Breather Fitting                                | 1          |
| 39            | 52102-B       | Standard Pipe Coupling, Common                  | 1          |
| 40            | 53902-B       | Close Nipple                                    | 1          |
| 41            | 118456        | Bearing Isolator                                | 1          |
| 42            | 118959        | Bearing Shield                                  | 1          |
| 43            | 53304-152     | Hose Clamp                                      | 1          |
| 44            | 98291         | Polypak Seal, 3.875 OD                          | 1          |
| 45            | 98290         | Upper Stem Liner                                | 1          |
| 46            | 53219-2       | Grease Fitting, Straight Extended (.125-27 NPT) | 3          |
| 47            | 50012-20-C5D  | Hex-head Cap Screw                              | 6          |
| 48            | 51216-24      | Dowel Pin                                       | 2          |





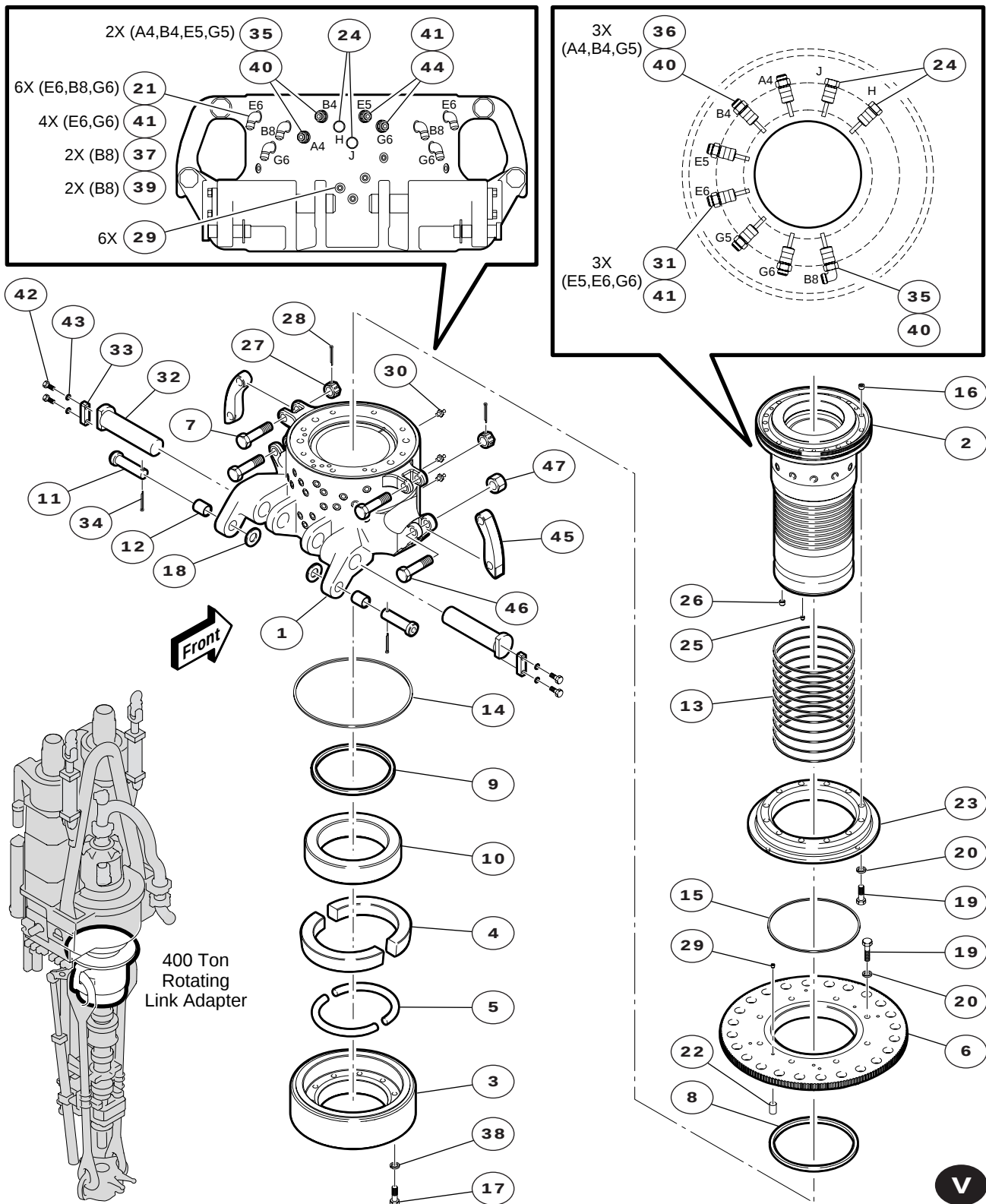


Figure 5-24. Rotating link adapter (400 Ton)

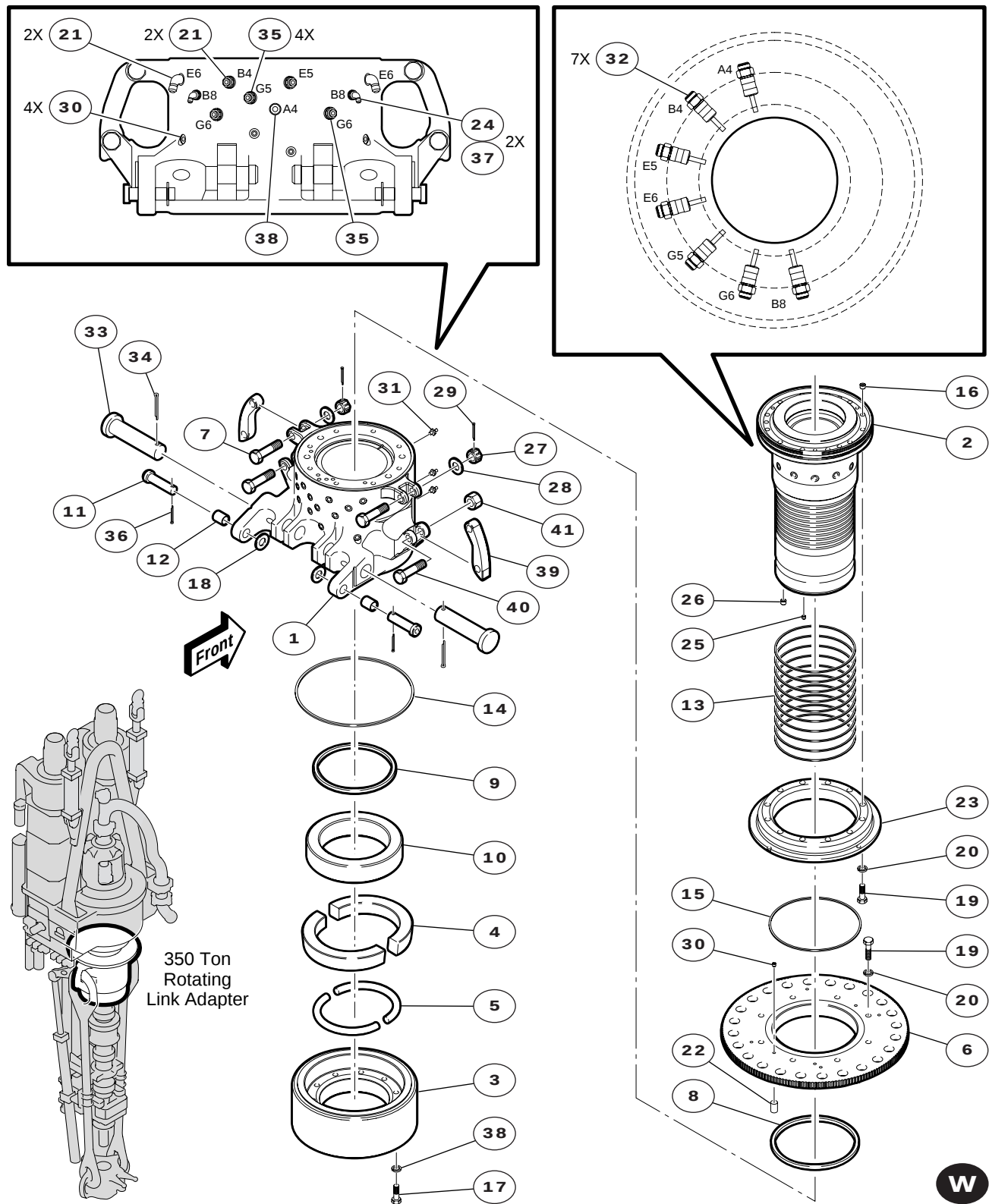
**Key to Figure 5-24. Rotating link adapter (400 Ton)**

| Item # | Part #       | Description                              | Qty |
|--------|--------------|------------------------------------------|-----|
| 1      | 112478       | Casting, 400 Ton                         | 1   |
| 2      | 112832       | Load Stem                                | 1   |
| 3      | 116254       | Retainer Cap                             | 1   |
| 4      | 116255       | Load Collar (set)                        | 1   |
| 5      | 103953       | Load Ring (set)                          | 1   |
| 6      | 109779       | Gear Set                                 | 1   |
| 7      | 114594       | Catch Link Bolt                          | 2   |
| 8      | 88099        | Bearing, 12" ID x 14" OD                 | 1   |
| 9      | 79854        | Bearing, 11" ID x 13" OD                 | 1   |
| 10     | 12811        | Thrust Bearing, BJ 12811                 | 1   |
| 11     | 110120       | Cylinder Pin                             | 2   |
| 12     | 110082       | Press Fit Bushing                        | 2   |
| 13     | 110548       | Rotary Seal, 11.500 Bore                 | 10  |
| 14     | 105599       | Lower V-Ring Seal                        | 1   |
| 15     | 11013        | Upper V-Ring Seal                        | 1   |
| 16     | 53000-8-C    | Countersunk Hex Pipe Plug, 1/2" NPT      | 18  |
| 17     | 50008-22-C5D | Hex-head Screw, 1/2-13 UNC x 2 3/4" long | 6   |
| 18     | 50822-R-C-5  | Flat Washer, 1 3/8"                      | 2   |
| 19     | 50012-30-C5D | Hex-head Screw, 3/4-10 UNC x 3 1/2" long | 20  |
| 20     | 50912-C      | Lock Washer, 3/4"                        | 20  |
| 21     | 56557-8-8-S  | 45° O-Ring Elbow, BOSS/37°, 1/2"         | 6   |
| 22     | 51216-16     | Dowel, 1.00" dia. x 2.00" long           | 4   |
| 23     | 109535       | Shear Ring Retainer                      | 1   |
| 24     | 56531-8-S    | O-Ring Plug, BOSS, 1/2"                  | 4   |

**Key to Figure 5-24. Rotating link adapter (400 Ton) (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                          | <b>Qty</b> |
|---------------|---------------|---------------------------------------------|------------|
| 25            | 53000-2-C     | Countersunk Hex Pipe Plug, 1/8" NPT         | 5          |
| 26            | 53000-6-C     | Countersunk Hex Pipe Plug, 3/8" NPT         | 4          |
| 27            | 50520-C       | Hex Nut, 1 1/4-7 UNC                        | 2          |
| 28            | 51405-24      | Cotter Pin, 5/16 x 3"                       | 2          |
| 29            | 53000-4-C     | Countersunk Hex Pipe Plug, 1/4" NPT         | 16         |
| 30            | 53201         | Grease Fitting                              | 3          |
| 31            | 56529-8-8-S   | O-Ring Connector, BOSS/37°, 1/2"            | 3          |
| 32            | 113355        | Pin                                         | 2          |
| 33            | 118947        | Retainer Bar                                | 2          |
| 34            | 51403-16      | Cotter Pin, 3/16 x 2"                       | 2          |
| 35            | 56519-8-6-S   | O-Ring Elbow, BOSS/37°                      | 3          |
| 36            | 56529-8-6-S   | O-Ring Connector, BOSS/37°                  | 3          |
| 37            | 56516-8-4-S   | Tube End Reducer                            | 2          |
| 38            | 50908-C       | Lock Washer, 1/2"                           | 6          |
| 39            | 53405         | Cap, 1/4"                                   | 2          |
| 40            | 53406         | Cap, 3/8"                                   | 6          |
| 41            | 53408         | Cap, 1/2"                                   | 9          |
| 42            | 50008-12-C5D  | Hex-head Cap Screw, 1/2-13 UNC x 1 1/4 long | 4          |
| 43            | 50908-C       | Lock Washer, Regular, 1/2"                  | 4          |
| 44            | 56519-8-8-S   | O-Ring Elbow, BOSS/37°                      | 2          |
| 45            | 113346        | Catch Link                                  | 2          |
| 46            | 50020-52-S    | Hex-head Cap Screw, 1 1/4 x 6.50"           | 2          |
| 47            | 50220-S       | Hex-head Nut, 1 1/4-7 UNC                   | 2          |





**Figure 5-25. Rotating link adapter (350 Ton)**

**Key to Figure 5-25. Rotating link adapter (350 Ton)**

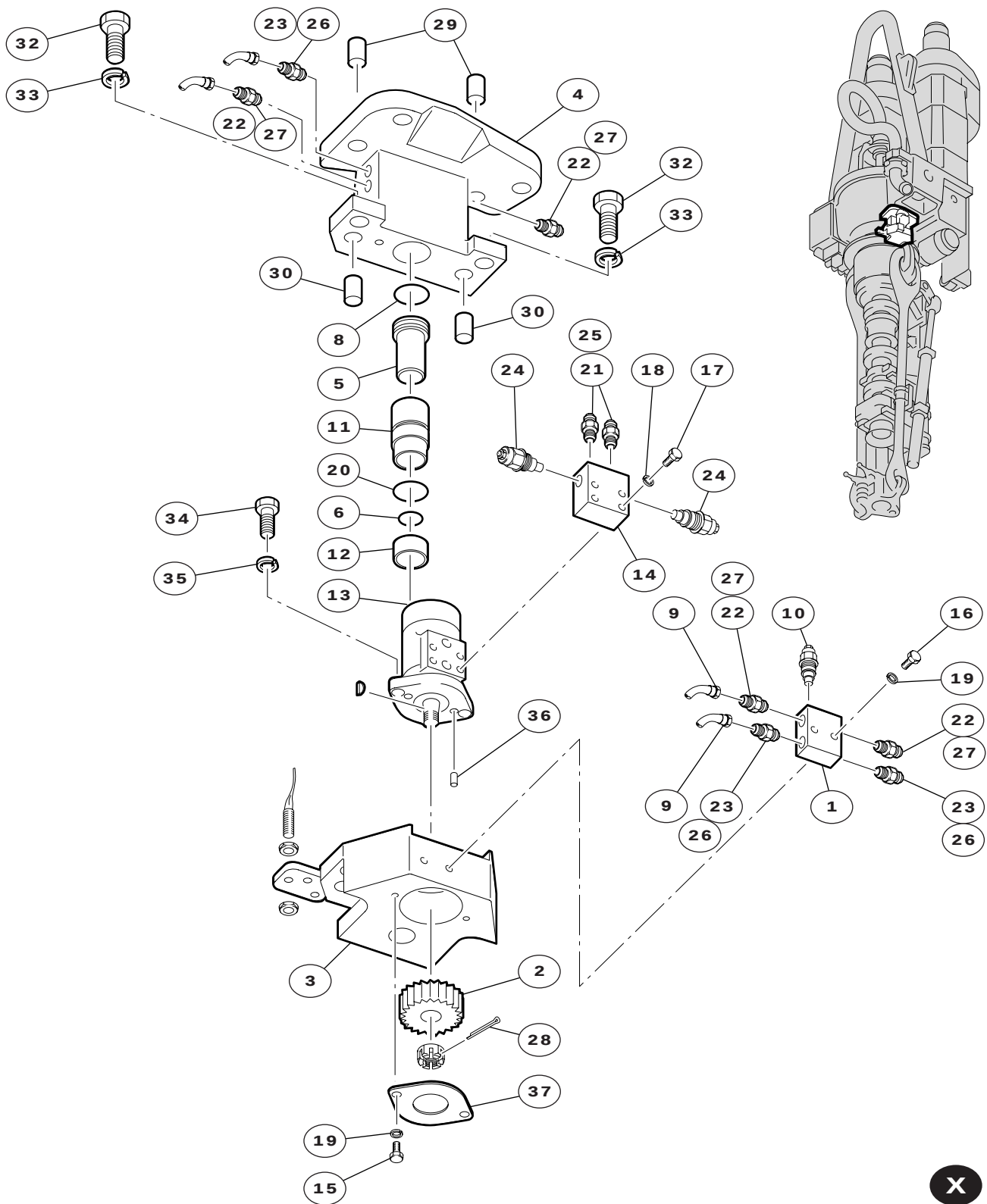
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                       | <b>Qty</b> |
|---------------|---------------|------------------------------------------|------------|
| 1             | 109588        | Casting, 350 Ton                         | 1          |
| 2             | 109590        | Load Stem                                | 1          |
| 3             | 110069        | Retainer Cap                             | 1          |
| 4             | 103952        | Load Collar (Set)                        | 1          |
| 5             | 103953        | Load Ring                                | 1          |
| 6             | 109779        | Gear Set (Matched)                       | 1          |
| 7             | 110127        | Catch Link Bolt                          | 2          |
| 8             | 88099         | Bearing, 12" ID x 14" OD                 | 1          |
| 9             | 79854         | Bearing, 11" ID x 13" OD                 | 1          |
| 10            | 12811         | Thrust Bearing, BJ 12811                 | 1          |
| 11            | 110120        | Cylinder Pin                             | 2          |
| 12            | 110082        | Press Fit Bushing                        | 2          |
| 13            | 110548        | Rotary Seal, 11.500 Bore                 | 8          |
| 14            | 105599        | Lower V-Ring Seal                        | 1          |
| 15            | 110113        | Upper V-Ring Seal                        | 1          |
| 16            | 53000-8-C     | Countersunk Hex Pipe Plug, 1/2" NPT      | 18         |
| 17            | 50012-34-C5D  | Hex-head Screw, 3/4-10 UNC x 4 1/4" long | 10         |
| 18            | 50822-R-C5    | Flat Washer, 1 3/8"                      | 2          |
| 19            | 50012-32-C5D  | Hex-head Screw, 3/4-10 UNC x 4" long     | 8          |
| 20            | 50912-C       | Lock Washer, 3/4"                        | 18         |
| 21            | 56502-8-8-S   | 45° Elbow Pipe Ext., 37°, 1/2"           | 2          |
| 22            | 51216-16      | Dowel, 1.00" dia. x 2.00" long           | 4          |
| 23            | 109535        | Shear Ring Retainer                      | 1          |
| 24            | 56502-4-4-S   | 45° Elbow Ext. Pipe/37°, 1/4"            | 2          |

**Key to Figure 5-25. Rotating link adapter (350 Ton) (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                   | <b>Qty</b> |
|---------------|---------------|--------------------------------------|------------|
| 25            | 53000-2-C     | Countersunk Hex Pipe Plug, 1/8" NPT  | 3          |
| 26            | 53000-6-C     | Countersunk Hex Pipe Plug, 3/8" NPT  | 4          |
| 27            | 50520-C       | Hex Nut, 1 1/4-7 UNC                 | 2          |
| 28            | 50820-R-C     | Flat Washer, 1 1/4"                  | 2          |
| 29            | 51405-24      | Cotter Pin, 5/16 x 3"                | 2          |
| 30            | 53000-4-C     | Countersunk Hex Pipe Plug, 1/4" NPT  | 8          |
| 31            | 53201         | Grease Fitting                       | 3          |
| 32            | 56529-8-8-S   | O-Ring Connector, BOSS/37°, 1/2"     | 7          |
| 33            | 112269        | Pin                                  | 2          |
| 34            | 51403-24      | Cotter Pin, 3/16" x 3"               | 2          |
| 35            | 56501-8-8-S   | Ext. Pipe Connector/37°, 1/2"        | 4          |
| 36            | 51403-16      | Cotter Pin, 3/16 x 2"                | 2          |
| 37            | 56700-8-4-S   | Pipe Reducer, 1/2" x 1/4"            | 2          |
| 38            | 56501-8-6-S   | Ext. Pipe Connector/37°, 1/2" x 3/8" | 2          |
| 39            | 110520        | Catch Link                           | 2          |
| 40            | 50020-44-S    | Hex-head Cap Screw, 1 1/4" x 5.50"   | 2          |
| 41            | 50220-S       | Hex-head Nut, 1 1/4-7 UNC            | 2          |







**Figure 5-26. Shot pin assembly**

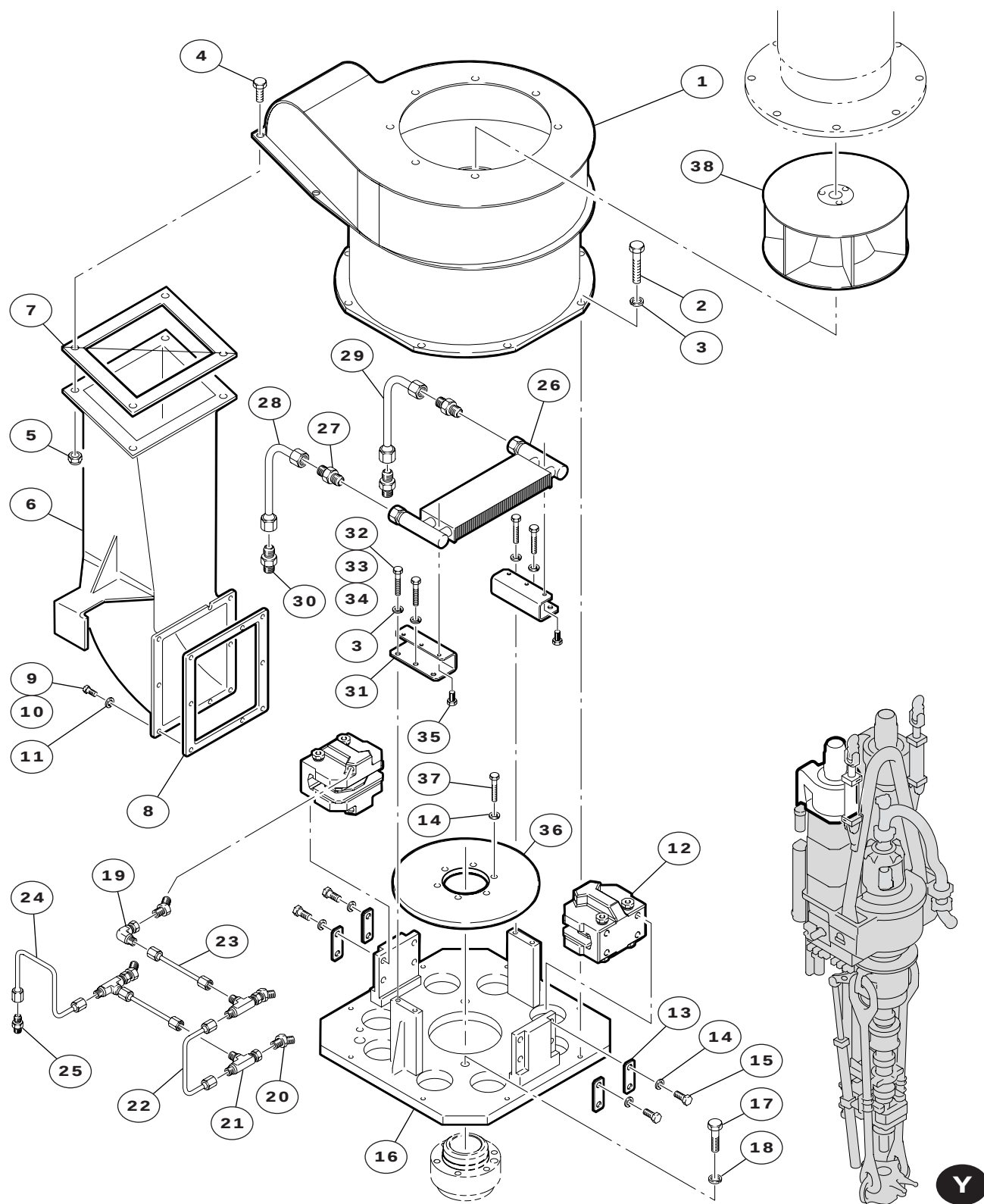
**Key to Figure 5-26. Shot pin assembly**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                     | <b>Qty</b> |
|---------------|---------------|----------------------------------------|------------|
| 1             | 110071-2      | Dual Port Line Body, T-10A             | 1          |
| 2             | 114366        | Pinon Gear                             | 1          |
| 3             | 112618        | Shot Pin Cap                           | 1          |
| 4             | 114598        | Shot Pin Base                          | 1          |
| 5             | 112621        | Shot Pin                               | 1          |
| 6             | 110056        | Rod Seal Assembly                      | 1          |
| 7             | 116145        | Shot Pin Tube Assembly                 | 1          |
| 8             | 110061        | Rod Seal Assembly                      | 1          |
| 9             | 116146        | Shot Pin Tube Assembly                 | 1          |
| 10            | 94522-1EN     | Relief Valve                           | 1          |
| 11            | 112625        | Shot Pin Sleeve                        | 1          |
| 12            | 112626        | Shot Pin Bearing                       | 1          |
| 13            | 114375        | Hydraulic Motor                        | 1          |
| 14            | 110163-2      | Direct Motor Mount Manifold, Dual Port | 1          |
| 15            | 50004-06-C5D  | Hex-head Cap Screw                     | 2          |
| 16            | 50004-14-C5D  | Hex-head Cap Screw                     | 2          |
| 17            | 50005-22-C5D  | Hex-head Cap Screw                     | 4          |
| 18            | 50905-C       | Lock Washer, Regular                   | 4          |
| 19            | 50904-C       | Lock Washer, Regular                   | 4          |
| 20            | 51300-226-B   | O-Ring                                 | 1          |
| 21            | 56519-6-6-S   | O-Ring Elbow, BOSS/37°                 | 2          |
| 22            | 56529-6-4-S   | O-Ring Connector, BOSS/37°             | 4          |
| 23            | 56529-6-6-S   | O-Ring Connector, BOSS/37°             | 3          |
| 24            | 94520-1AN     | Relief Valve                           | 2          |

**Key to Figure 5-26. Shot pin assembly (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>               | <b>Qty</b> |
|---------------|---------------|----------------------------------|------------|
| 25            | 56544-8-S     | Cap, Female 37° Seat (1/2T)      | 2          |
| 26            | 56544-6-S     | Cap, Female 37° Seat (3/8T)      | 3          |
| 27            | 56544-4-S     | Cap, Female 37° Seat (1/4T)      | 2          |
| 28            | 51402-10-S    | Cotter Pin                       | 1          |
| 29            | 51216-10      | Dowel Pin                        | 2          |
| 30            | 51216-14      | Dowel Pin                        | 2          |
| 31            | 112627        | Shot Pin Cover                   | 1          |
| 32            | 50016-18-C5D  | Hex-head Cap Screw               | 2          |
| 33            | 50916-C       | Lock Washer, Regular             | 2          |
| 34            | 50008-10-C5D  | Hex-head Cap Screw               | 2          |
| 35            | 50908-C       | Lock Washer, Regular             | 2          |
| 36            | 51204-6       | Dowel Pin, .2501 dia. x .75 long | 2          |





**Figure 5-27. AC motor brake assembly, left**

**Key to Figure 5-27. AC motor brake assembly, left**

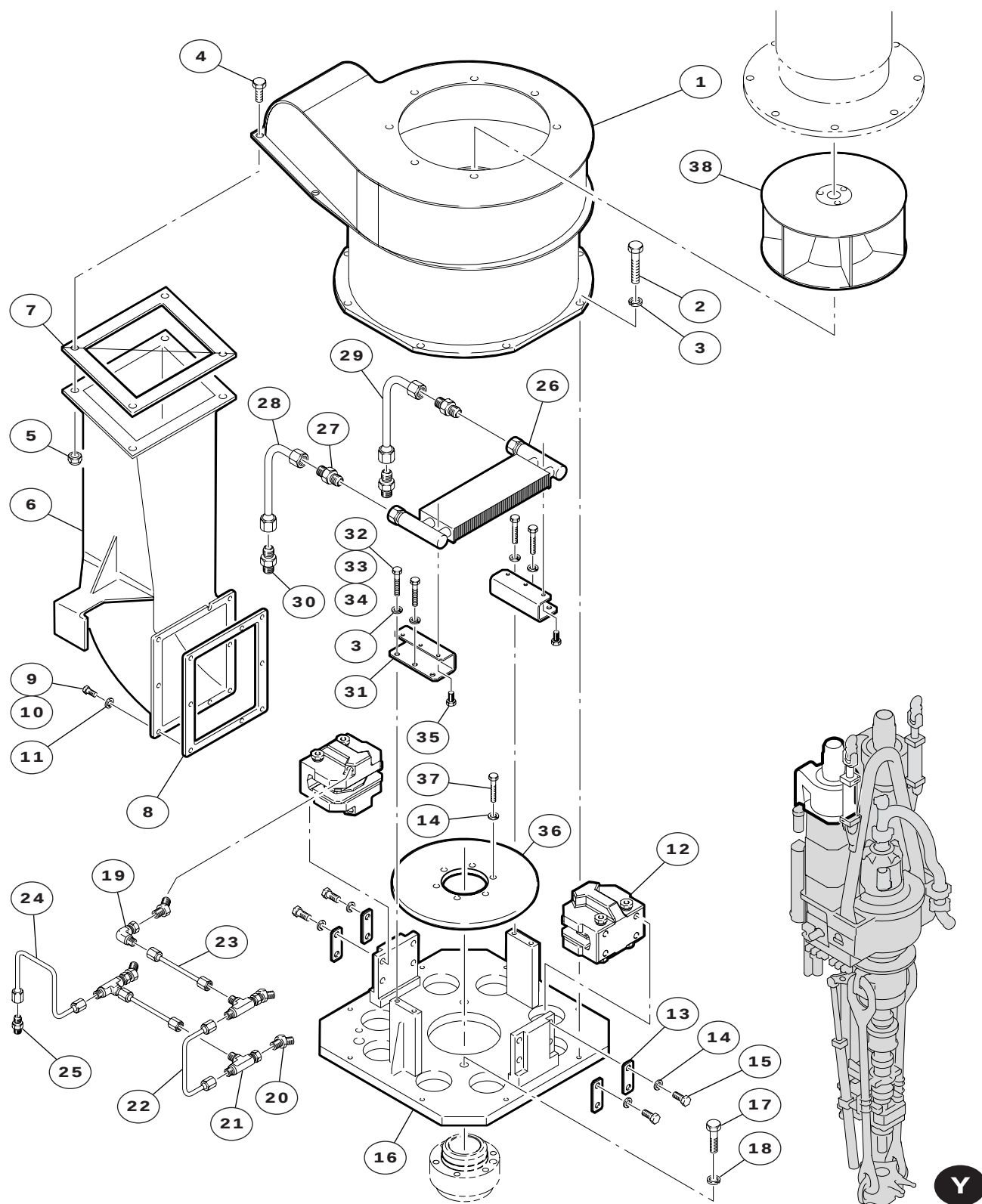
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>           | <b>Qty</b> |
|---------------|---------------|------------------------------|------------|
| 1             | 109592-2      | Blower Scroll Brake Cover    | 1          |
| 2             | 50006-10-C5D  | Hex-head Cap Screw           | 8          |
| 3             | 50906-C       | Lock Washer, Regular         | 8          |
| 4             | 50006-10-C5   | Hex-head Cap Screw           | 4          |
| 5             | 51806-C       | Self-Locking Nut             | 4          |
| 6             | 109563-2      | Duct                         | 1          |
| 7             | 110110        | Blower/Duct Gasket           | 1          |
| 8             | 110116        | Duct/Motor Gasket            | 1          |
| 9             | 50005-8-C5D   | Hex-head Cap Screw           | 3          |
| 10            | 50005-12-C5D  | Hex-head Cap Screw           | 6          |
| 11            | 50905-C       | Lock Washer, Regular         | 9          |
| 12            | 109528        | Caliper Disc Brake           | 2          |
| 13            | 109557        | Washer                       | 4          |
| 14            | 50908-C       | Lock Washer, Regular         | 14         |
| 15            | 50008-9-C5D   | Hex-head Cap Screw           | 8          |
| 16            | 109553        | Brake Adapter Plate          | 1          |
| 17            | 50010-10-C5D  | Hex-head Cap Screw           | 4          |
| 18            | 50910-C       | Lock Washer, Regular         | 4          |
| 19            | 56502-2-4-S   | 45° O-Ring Elbow, BOSS/37°   | 4          |
| 20            | 56518-4-4-S   | Swivel Elbow, Int. 37°/37°   | 1          |
| 21            | 56525-4-4-S   | Swivel Tee, Int. 37°/37°/37° | 3          |
| 22            | 117115        | Brake Tube Assembly          | 1          |
| 23            | 110171        | Brake Tube Assembly          | 2          |
| 24            | 117116        | Brake Tube Assembly          | 1          |

**Key to Figure 5-27. AC motor brake assembly, left (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                               | <b>Qty</b> |
|---------------|---------------|--------------------------------------------------|------------|
| 25            | 56529-4-4-S   | O-Ring Connector, BOSS/37°                       | 1          |
| 26            | 110170        | Oil Heat Exchanger                               | 1          |
| 27            | 56501-12-8-S  | Ext. Pipe Connector, 37°                         | 2          |
| 28            | 111827-2      | Heat Exchanger Tube, 1/2"                        | 1          |
| 29            | 111827-1      | Heat Exchanger Tube, 1/2"                        | 1          |
| 30            | 56529-8-8-S   | O-Ring Connector, BOSS/37°                       | 2          |
| 31            | 114237        | Heat Exchanger Bracket                           | 2          |
| 32            | 110078-FL2    | Safety Cable, .032 dia. Ferrule (50 in magazine) | 2          |
| 33            | 110078-L18    | Safety Cable, .032 dia.                          | 10         |
| 34            | 50006-6-C5D   | Hex-head Cap Screw                               | 4          |
| 35            | 50004-6-C5D   | Hex-head Cap Screw                               | 4          |
| 36            | 109555        | Brake Rotor                                      | 1          |
| 37            | 50008-10-C5D  | Hex-head Cap Screw                               | 6          |
| 38            | 109561        | Blower Impeller                                  | 1          |







**Figure 5-28. AC motor brake assembly, right**

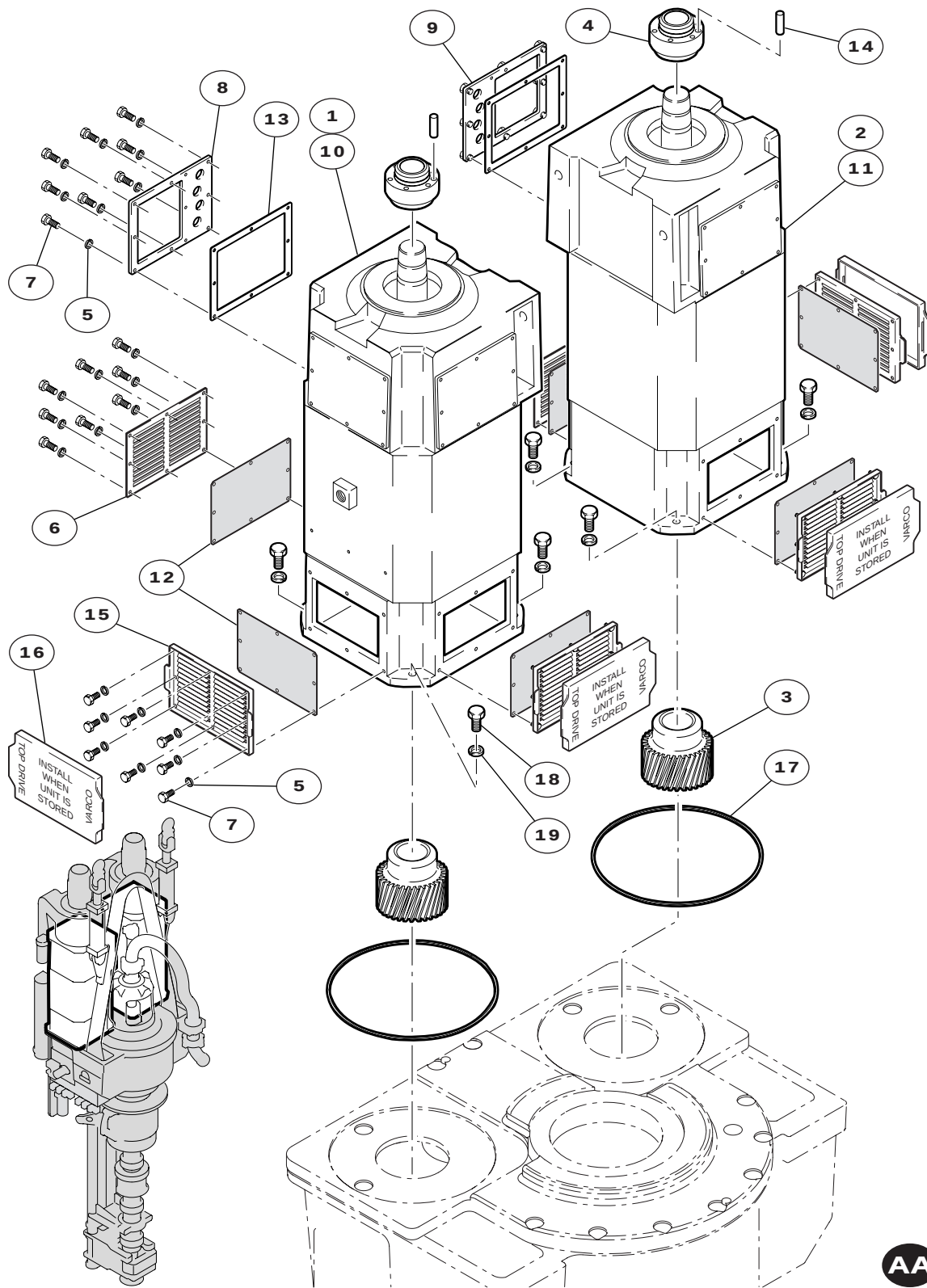
**Key to Figure 5-28. AC motor brake assembly, right**

| Item # | Part #       | Description                  | Qty |
|--------|--------------|------------------------------|-----|
| 1      | 109592-2     | Blower Scroll Brake Cover    | 1   |
| 2      | 50006-10-C5D | Hex-head Cap Screw           | 12  |
| 3      | 50906-C      | Lock Washer, Regular         | 12  |
| 4      | 50006-10-C5  | Hex-head Cap Screw           | 4   |
| 5      | 51806-C      | Self-Locking Nut             | 4   |
| 6      | 109563-2     | Duct                         | 1   |
| 7      | 110110       | Blower/Duct Gasket           | 1   |
| 8      | 110116       | Duct/Motor Gasket            | 1   |
| 9      | 50005-8-C5D  | Hex-head Cap Screw           | 3   |
| 10     | 50005-12-C5D | Hex-head Cap Screw           | 6   |
| 11     | 50905-C      | Lock Washer, Regular         | 8   |
| 12     | 109528       | Caliper Disc Brake           | 2   |
| 13     | 109557       | Washer                       | 4   |
| 14     | 50908-C      | Lock Washer, Regular         | 14  |
| 15     | 50008-9-C5D  | Hex-head Cap Screw           | 8   |
| 16     | 109553       | Brake Adapter Plate          | 1   |
| 17     | 50010-10-C5D | Hex-head Cap Screw           | 4   |
| 18     | 50910-C      | Lock Washer, Regular         | 4   |
| 19     | 56502-2-4-S  | 45° O-Ring Elbow, BOSS/37°   | 4   |
| 20     | 56518-4-4-S  | Swivel Elbow, Int. 37°/37°   | 1   |
| 21     | 56525-4-4-S  | Swivel Tee, Int. 37°/37°/37° | 3   |
| 22     | 117115       | Brake Tube Assembly          | 1   |
| 23     | 110171       | Brake Tube Assembly          | 2   |
| 24     | 115299       | Digital Encoder              | 1   |

**Key to Figure 5-28. AC motor brake assembly, right (continued)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>    | <b>Qty</b> |
|---------------|---------------|-----------------------|------------|
| 25            | 50103-5-BD    | Socket-head Cap Screw | 4          |
| 26            | 50903-C       | Flat Washer, Regular  | 4          |
| 27            | 120113        | Encoder Mount         | 1          |
| 28            | 50004-4-C5D   | Hex-head Cap Screw    | 4          |
| 29            | 50804-N-S     | Flat Washer, Narrow   | 5          |
| 30            | 50904-C       | Lock Washer, Regular  | 8          |
| 31            | 120115        | Spring                | 1          |
| 32            | 120112        | Sled Mount            | 1          |
| 33            | 50004-5-C5D   | Hex-head Cap Screw    | 2          |
| 34            | 120114        | Adapter Mount         | 1          |
| 35            | 120117        | Timing Belt           | 1          |
| 36            | 120119-2      | Timing Pulley         | 1          |
| 37            | 120119-1      | Timing Pulley         | 1          |
| 38            | 120116        | Adapter Shaft         | 1          |
| 39            | 50104-8-S     | Socket-head Cap Screw | 2          |
| 40            | 109555        | Brake Rotor           | 1          |
| 41            | 50008-10-C5D  | Hex-head Cap Screw    | 6          |
| 42            | 109561        | Blower Impeller       | 1          |



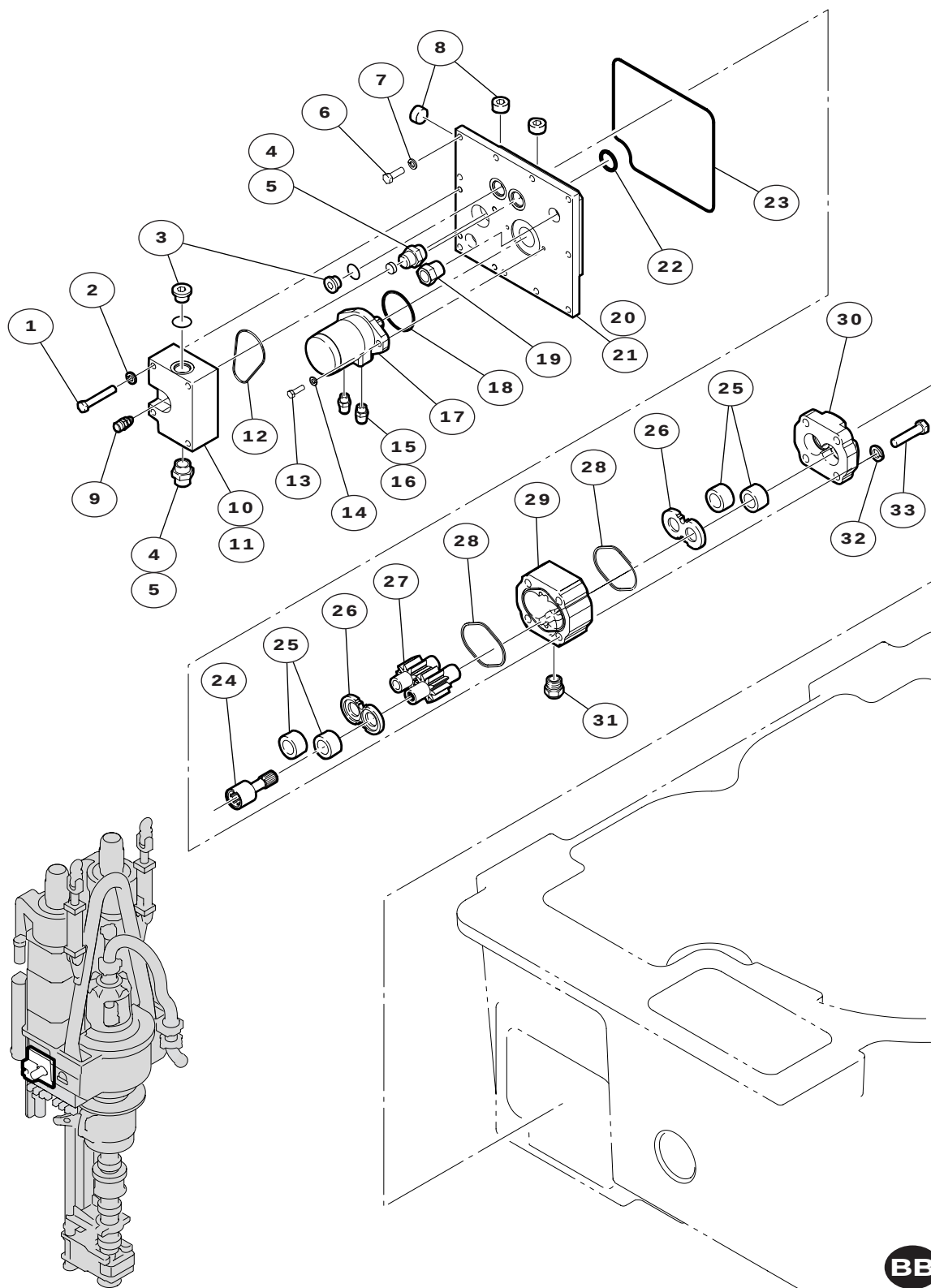


AA

Figure 5-29. AC motor assembly

**Key to Figure 5-29. AC motor assembly**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>          | <b>Qty</b> |
|---------------|---------------|-----------------------------|------------|
| 1             | 108235-35R60  | AC Motor                    | 1          |
| 2             | 108235-35L60  | AC Motor                    | 1          |
| 3             | 109509        | Pinion Gear                 | 2          |
| 4             | 109554        | Brake Hub                   | 2          |
| 5             | 50905-C       | Lock Washer, Regular        | 84         |
| 6             | 113618        | Motor Louver                | 2          |
| 7             | 50005-6-C5D   | Hex-head Cap Screw          | 84         |
| 8             | 110109-1      | Duct Plate-Blower           | 1          |
| 9             | 110109-2      | Duct Plate-Blower           | 1          |
| 10            | 108235-35R46  | AC Motor                    | 1          |
| 11            | 108235-35L46  | AC Motor                    | 1          |
| 12            | 113619        | Louver Screen               | 6          |
| 13            | 110111        | Gasket                      | 2          |
| 14            | 51208-14      | Dowel Pin                   | 2          |
| 15            | 120994        | Drill Motor Louver          | 4          |
| 16            | 120995        | Drill Motor Louver Cover    | 4          |
| 17            | 51300-387-F   | Motor/Cover O-Ring          | 2          |
| 18            | 50012-18-C5D  | Hex-head Cap Screw (UNC-2A) | 8          |
| 19            | 50910-C       | Lock Washer, Regular        | 8          |



**Figure 5-30. Gearbox lube pump assembly**

**Key to Figure 5-30. Gearbox lube pump assembly**

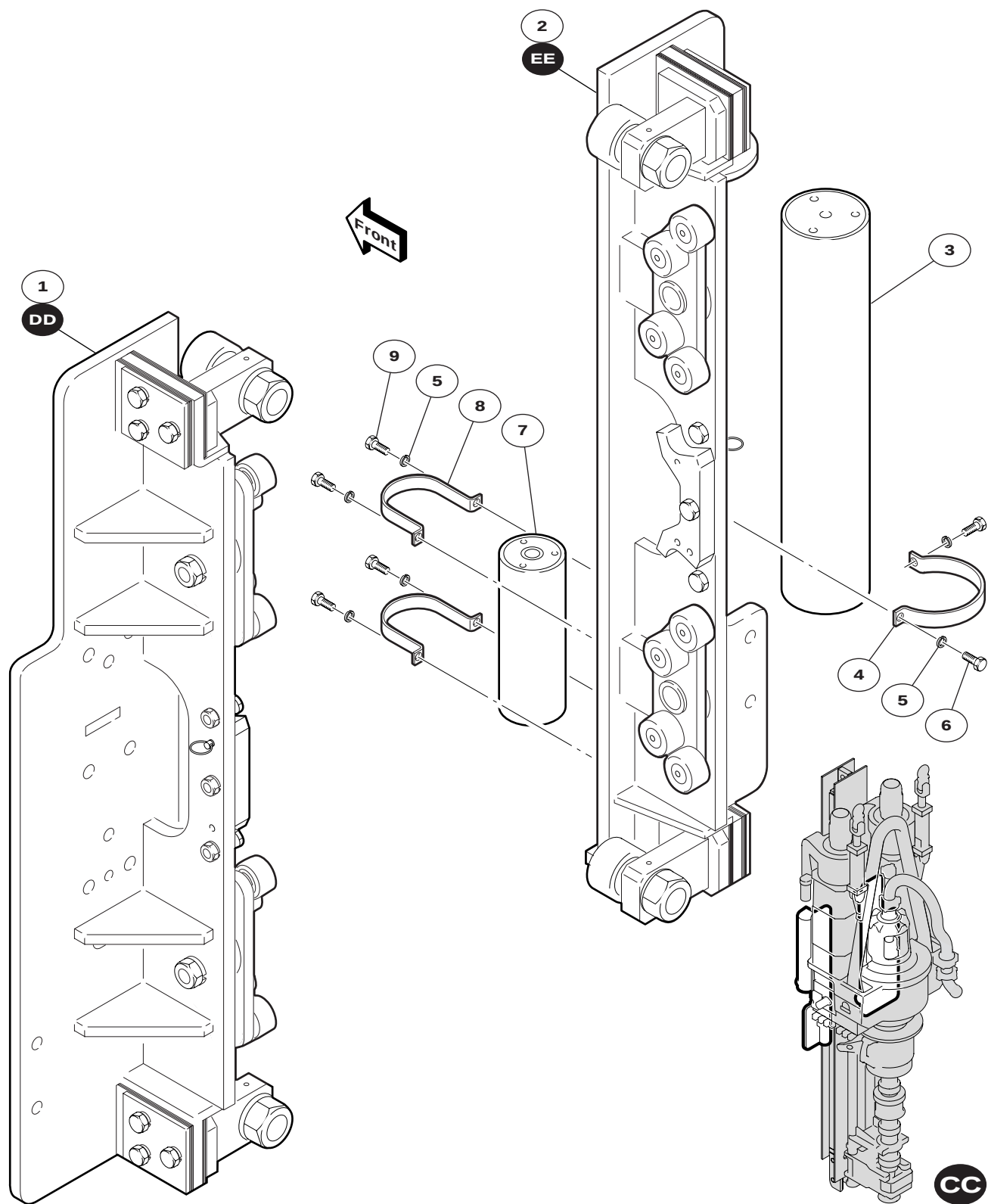
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                            | <b>Qty</b> |
|---------------|---------------|-----------------------------------------------|------------|
| 1             | 50008-30-C5D  | Hex-head Cap Screw                            | 4          |
| 2             | 50908-C       | Lock Washer, Regular                          | 4          |
| 3             | 87196-16      | Straight Thread Plug, Hollow Hex, with O-Ring | 2          |
| 4             | 56529-16-16-S | O-Ring Connector, BOSS/37°                    | 2          |
| 5             | 53418         | Plastic Pipe Closure Plug                     | 2          |
| 6             | 50008-12-C5D  | Hex-head Cap Screw                            | 10         |
| 7             | 50908-C       | Lock Washer, Regular                          | 10         |
| 8             | 53000-16-C    | External Pipe Plug, Countersunk Hex           | 3          |
| 9             | 93024-6SAE    | Test Fitting (SAE-6)                          | 1          |
| 10            | 109581        | Thermostat Housing (Steel)                    | 1          |
| 11            | 109581-1      | Thermostat Housing (Alum. Alloy)              | 1          |
| 12            | 51300-246-B   | O-Ring                                        | 1          |
| 13            | 50006-10-C5D  | Hex-head Cap Screw                            | 2          |
| 14            | 50906-C       | Lock Washer, Regular                          | 2          |
| 15            | 53408         | Plastic Pipe Closure Plug                     | 2          |
| 16            | 56529-10-8-S  | O-Ring Connector, BOSS/37°                    | 2          |
| 17            | 110161-49C    | Hydraulic Motor, Low Speed/High Torque        | 1          |
| 18            | 51300-152-B   | O-Ring                                        | 1          |
| 19            | 108119-16B    | Sight Gauge                                   | 1          |
| 20            | 109582-1      | Lube Pump Adapter Plate (Alum. Alloy)         | 1          |
| 21            | 109582        | Lube Pump Adapter Plate (Steel)               | 1          |
| 22            | 51300-223-F   | Main Body/Oil Gallery O-Ring                  | 2          |
| 23            | 51300-279-B   | Main Body/Oil Pump Adapter O-Ring             | 1          |
| 24            | 109579        | Motor/Pump Adapter                            | 1          |



***Key to Figure 5-30. Gearbox lube pump assembly (continued)***

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>             | <b>Qty</b> |
|---------------|---------------|--------------------------------|------------|
| 25            | 109567-B      | P50 Pump (Roller Bearing)      | 4          |
| 26            | 109567-T      | P50 Pump (Thrust Plate)        | 2          |
| 27            | 109567-G20    | P50 Pump (Gear Set)            | 1          |
| 28            | 109567-S      | P50 Pump (Body Seal)           | 2          |
| 29            | 109567-H203   | P50 Pump (Gear Housing)        | 1          |
| 30            | 109567-E      | P50 Pump (End Cover)           | 1          |
| 31            | 108465-24     | Shipping Plug, SAE O-Ring Port | 1          |
| 32            | 50910-C       | Lock Washer, Regular           | 4          |
| 33            | 50010-40-C5D  | Hex-head Cap Screw             | 4          |

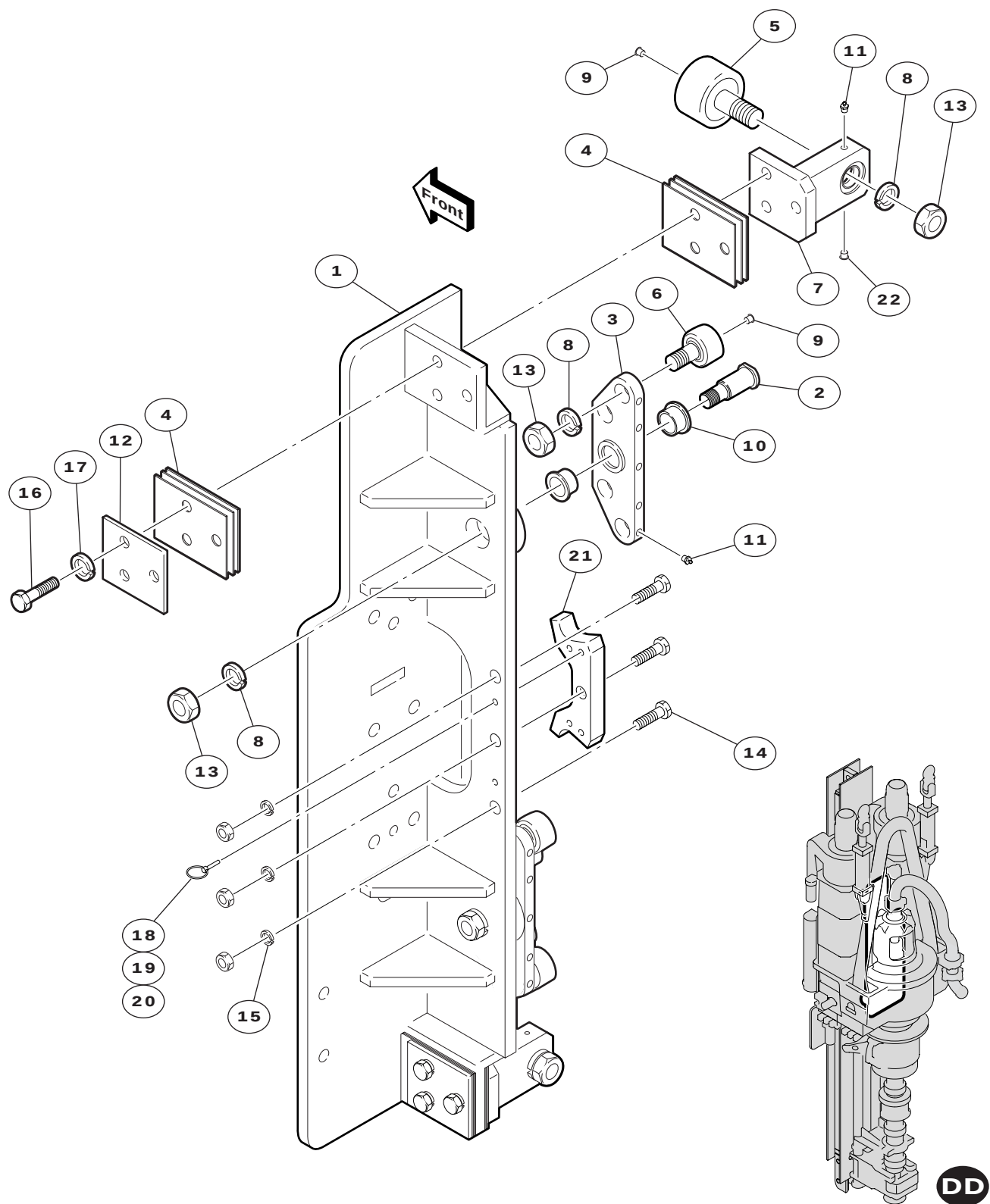




**Figure 5-31. Carriage/accumulator (roller)**

***Key to Figure 5-31. Carriage/accumulator (roll)***

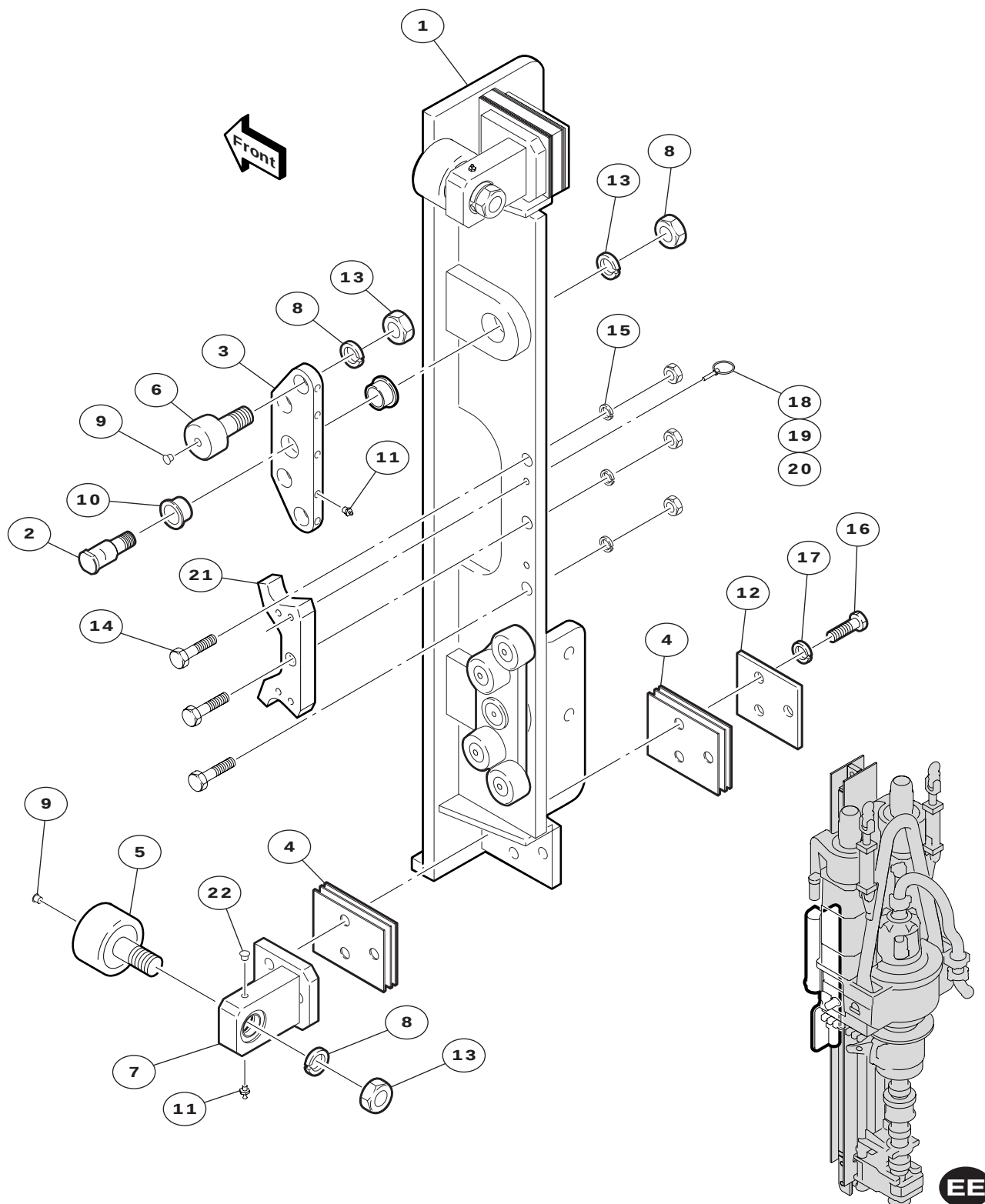
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>                     | <b>Qty</b> |
|---------------|---------------|----------------------------------------|------------|
| 1             | 113450        | Carriage Assembly, Right (30" setback) | 1          |
| 2             | 113448        | Carriage Assembly, Left (30" setback)  | 1          |
| 3             | 110562        | Hydro-Pneumatic Accumulator, 6"        | 1          |
| 4             | 113370        | Accumulator Strap, 6" dia.             | 1          |
| 5             | 50908-C       | Lock Washer, Regular                   | 6          |
| 6             | 50108-10-CD   | Socket-head Cap Screw, 1/2 UNC x 1.25  | 2          |
| 7             | 110563        | Hydro-Pneumatic Accumulator, 4"        | 1          |
| 8             | 88710         | Align Accumulator Mount Strap          | 2          |
| 9             | 50008-10-C5D  | Hex-head Cap Screw                     | 4          |



**Figure 5-32. Carriage assembly, right (roller)**

**Key to Figure 5-32. Carriage assembly, right (roller)**

| Item # | Part #       | Description                              | Qty |
|--------|--------------|------------------------------------------|-----|
| 1      | 113449       | Carriage, Right                          | 1   |
| 2      | 112875       | Bogey Pivot Pin                          | 2   |
| 3      | 112876       | Bogey                                    | 2   |
| 4      | 109903       | Shim, 1/8"                               | 12  |
| 5      | 113285       | Cam Follower, 6" dia.                    | 2   |
| 6      | 80784        | Roller, 4" dia., Crowned, Modified       | 8   |
| 7      | 109904       | Side Roller Bracket                      | 2   |
| 8      | 51132-C      | Lock Washer, Hi-Collar, 2" dia.          | 12  |
| 9      | 53000-4-C    | Plug, 1/4" NPT                           | 10  |
| 10     | 109944       | Flanged Bushing, 2.75 ID                 | 4   |
| 11     | 53209        | Grease Fitting, 1/8"-27 NPT              | 12  |
| 12     | 10994        | Sandwich Plate                           | 2   |
| 13     | 80569        | Jam Nut, 2"-12 UN-2B                     | 12  |
| 14     | 50016-28-C5D | Hex-head Cap Screw, 1" UNC x 3.5" long   | 3   |
| 15     | 51016-C      | Lock Washer, 1.0" dia.                   | 3   |
| 16     | 50012-24-C5D | Hex-head Cap Screw, 3/4" UNC x 3.0" long | 6   |
| 17     | 51012-C      | Lock Washer, 3/4"                        | 6   |
| 18     | 51220-2      | Retaining Cable, .063 dia.               |     |
| 19     | 51219-2      | Cable Ferrule                            | 2   |
| 20     | 51221-6-K    | Detent Pin, 1/2" dia. x 2.75" long       | 1   |
| 21     | 109995       | Chock                                    | 1   |
| 22     | 53000-2-C    | Plug, 1/8" NPT                           | 2   |

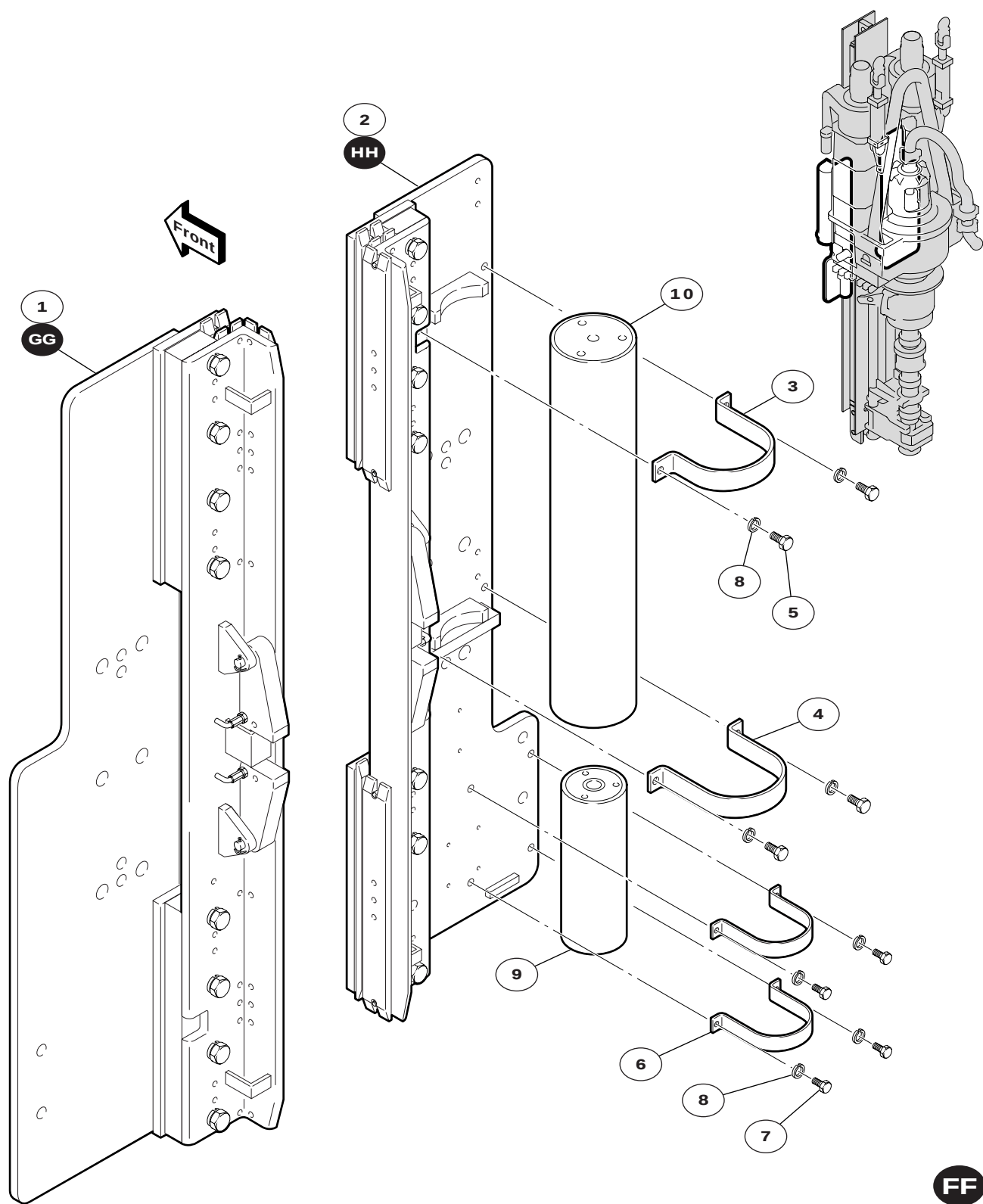


**Figure 5-33. Carriage assembly, left (roller)**

**Key to Figure 5-33. Carriage assembly, left (roller)**

| Item # | Part #       | Description                              | Qty |
|--------|--------------|------------------------------------------|-----|
| 1      | 113447       | Carriage, Left                           | 1   |
| 2      | 112875       | Bogey Pivot Pin                          | 2   |
| 3      | 112876       | Bogey                                    | 2   |
| 4      | 109903       | Shim, 1/8"                               | 12  |
| 5      | 113285       | Cam Follower, 6" dia.                    | 2   |
| 6      | 80784        | Roller, 4" dia., Crowned, Modified       | 8   |
| 7      | 109904       | Side Roller Bracket                      | 2   |
| 8      | 51132-C      | Lock Washer, Hi-Collar, 2" dia.          | 12  |
| 9      | 53000-4-C    | Plug, 1/4" NPT                           | 10  |
| 10     | 109944       | Flanged Bushing, 2.75 ID                 | 4   |
| 11     | 53209        | Grease Fitting, 1/8"-27 NPT              | 12  |
| 12     | 10994        | Sandwich Plate                           | 2   |
| 13     | 80569        | Jam Nut, 2"-12 UN-2B                     | 12  |
| 14     | 50016-28-C5D | Hex-head Cap Screw, 1" UNC x 3.5" long   | 3   |
| 15     | 51016-C      | Lock Washer, 1.0" dia.                   | 3   |
| 16     | 50012-24-C5D | Hex-head Cap Screw, 3/4" UNC x 3.0" long | 6   |
| 17     | 51012-C      | Lock Washer, 3/4"                        | 6   |
| 18     | 51220-2      | Retaining Cable, .063 dia.               |     |
| 19     | 51219-2      | Cable Ferrule                            | 2   |
| 20     | 51221-6-K    | Detent Pin, 1/2" dia. x 2.75" long       | 1   |
| 21     | 109995       | Chock                                    | 1   |
| 22     | 53000-2-C    | Plug, 1/8" NPT                           | 2   |

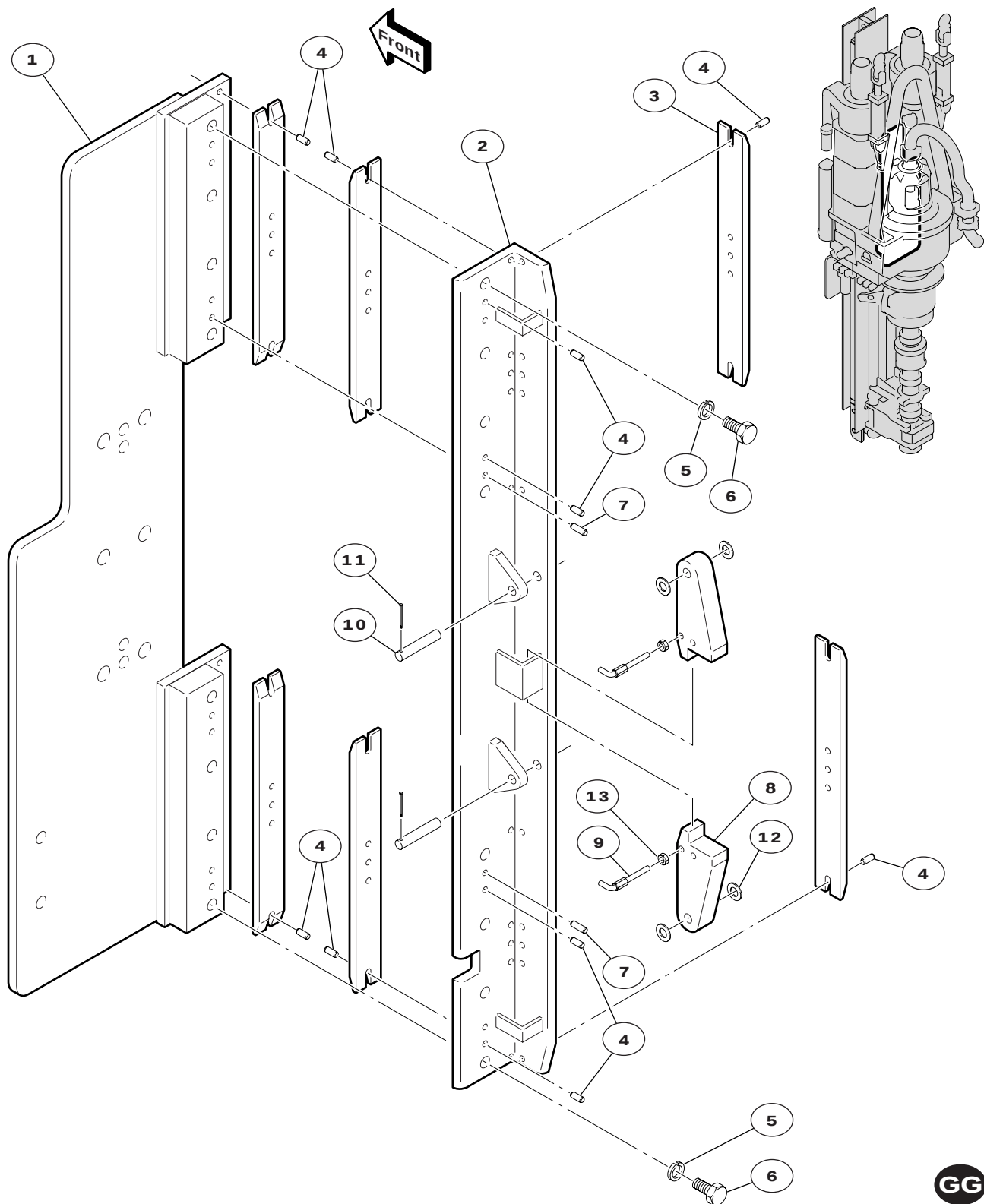




**Figure 5-34. Carriage/accumulator (skid)**

***Key to Figure 5-34. Carriage/accumulator (skid)***

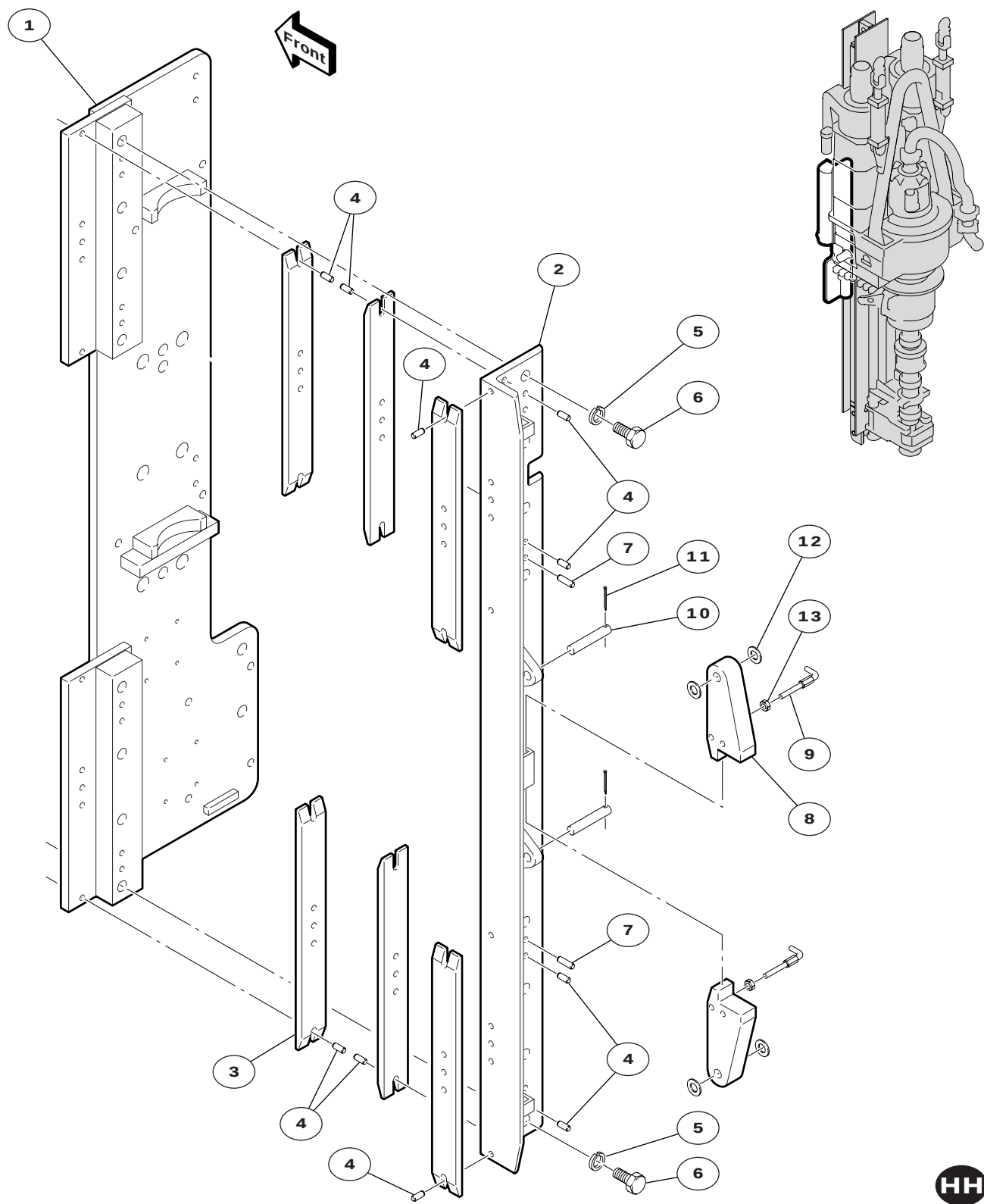
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>              | <b>Qty</b> |
|---------------|---------------|---------------------------------|------------|
| 1             | 117594        | Carriage Assembly, Right        | 1          |
| 2             | 117593        | Carriage Assembly, Left         | 1          |
| 3             | 117621-1      | Accumulator Strap, Long         | 1          |
| 4             | 117621-2      | Accumulator Strap, Short        | 1          |
| 5             | 50008-10-C5D  | Hex-head Cap Screw              | 4          |
| 6             | 88710         | Align Accumulator Mount Strap   | 2          |
| 7             | 50008-8-C5D   | Hex-head Cap Screw              | 4          |
| 8             | 50908-C       | Lock Washer, Regular            | 8          |
| 9             | 110563        | Hydro-Pneumatic Accumulator, 4" | 1          |
| 10            | 110562        | Hydro-Pneumatic Accumulator, 6" | 1          |



**Figure 5-35. Carriage assembly, right (skid)**

**Key to Figure 5-35. Carriage assembly, right (skid)**

| <b>Item #</b> | <b>Part #</b> | <b>Description</b>          | <b>Qty</b> |
|---------------|---------------|-----------------------------|------------|
| 1             | 117592        | Carriage, Right (machining) | 1          |
| 2             | 117586        | Carriage Angle (machining)  | 1          |
| 3             | 117588        | Skid Pad                    | 6          |
| 4             | 51608-8       | Roll Pin                    | 34         |
| 5             | 50912-C       | Lock Washer, Regular        | 8          |
| 6             | 50012-14-C5D  | Hex-head Cap Screw          | 8          |
| 7             | 51608-12      | Roll Pin                    | 2          |
| 8             | 117870        | Chock                       | 2          |
| 9             | 117871        | Plunger, Hand Retractable   | 2          |
| 10            | 56412-30-SHP  | Clevis Pin                  | 2          |
| 11            | 51402-10-S    | Cotter Pin                  | 2          |
| 12            | 50812-N-C     | Flat Washer, Narrow         | 4          |
| 13            | 50310-C       | Hex-Jam Nut                 | 2          |



**Figure 5-36. Carriage assembly, left (skid)**

***Key to Figure 5-36. Carriage assembly, left (skid)***

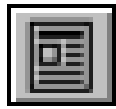
| <b>Item #</b> | <b>Part #</b> | <b>Description</b>         | <b>Qty</b> |
|---------------|---------------|----------------------------|------------|
| 1             | 117591        | Carriage, Left (machining) | 1          |
| 2             | 117586        | Carriage Angle (machining) | 1          |
| 3             | 117588        | Skid Pad                   | 6          |
| 4             | 51608-8       | Roll Pin                   | 34         |
| 5             | 50912-C       | Lock Washer, Regular       | 8          |
| 6             | 50012-14-C5D  | Hex-head Cap Screw         | 8          |
| 7             | 51608-12      | Roll Pin                   | 2          |
| 8             | 117870        | Chock                      | 2          |
| 9             | 117871        | Plunger, Hand Retractable  | 2          |
| 10            | 56412-29-SHP  | Clevis Pin                 | 2          |
| 11            | 51402-10-S    | Cotter Pin                 | 2          |
| 12            | 50812-N-C     | Flat Washer, Narrow        | 4          |
| 13            | 50310-C       | Hex-Jam Nut                | 2          |

March 9, 1998

# Adobe Acrobat Navigation

Below are the buttons that appear in your toolbar of this document. In order to view a document, please select the hand tool. If a document has been linked, the hand will point.

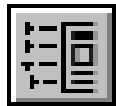
---



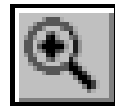
View Page



Hand



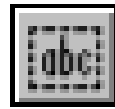
View Bookmarks



Zoom In

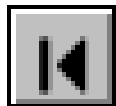


View Thumbnails



Select Text

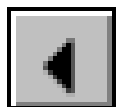
---



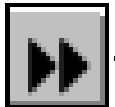
Return to First Page



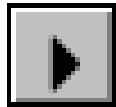
Go Back



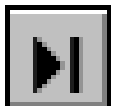
Return to  
Previous Page



Go Forward

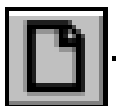


Go to  
Next Page



Go to  
Last Page

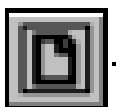
---



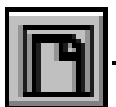
100% Zoom



Find



Fit Page



Fit Page Width  
Inside Window